REPORT OF PROCEEDINGS

OF THE

EIGHTH ANNUAL CONVENTION

OF THE

American Railway Master Mechanics'

ASSOCIATION,

HELD IN THE

CITY OF NEW YORK,

May 11th, 12th, and 13th, 1875.

CINCINNATI:
WILSTACH, BALDWIN & CO.,
RAILWAY PRINTERS AND MANUFACTURING STATIONERS.
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AMERICAN RAILWAY

Master Mechanics' Association.

OFFICERS FOR 1875.

PRESIDENT,

H. M. BRITTON, of Cincinnati.

FIRST VICE-PRESIDENT,

N. E. CHAPMAN, of Cleveland.

SECOND VICE-PRESIDENT,

W. A. ROBINSON, of Canada West.

TREASURER,

S. J. HAYES, of Chicago.

SECRETARY,

J. H. SETCHEL, of Cincinnati.

REPORT.

The Eighth Annual Convention of the American Railway Master Mechanics' Association assembled in the Hall of the Cooper Institute, in the city of New York, May 11th, 1875.

PRESIDENT H. M. BRITTON in the Chair, and the following officers present:

N. E. CHAPMAN, Cleveland & Pittsburgh R. R., FIRST VICE-PRESIDENT.

W. A. ROBINSON, Great Western R. R., of Canada, SECOND VICE-PRESIDENT.

S. J. HAYES, Illinois Central R. R., TREASURER.

J. H. SETCHEL, Little Miami R. R., Secretary.

The session was opened with prayer, by the Rev. J. M. Pullman of New York.

On motion, the minutes of the last session were received and approved without reading.

THE PRESIDENT—The first business in order is the calling of the roll, after which there will be an opportunity given for all who are eligible and desire to become members to sign the Constitution.

The following members responded to the call of the roll:

NAME.	ROAD.	ADDRESS.
ANDERSON, H		156 Lake St., Chicago.
BRITTON, H. M		Cincinnati, Ohio.
BOON, J. M	Pittsburgh, Fort Wayne & Chicago	Fort Wayne, Ind.
BUSHNELL, R. W	Burlington, Cedar Rapids & Minn	Cedar Rapids, Iowa.
BROWN, H. L	Late of Erie	Paterson, N. J.
BLACKALL, R. C	Albany & Susquehanna	Albany, N. Y.
BOYDEN, G. E	Boston, Hartford & Erie	Boston, Mass.
BROOKS, H. G	Brooks Locomotive Works	Dunkirk, N. Y.
BRITTON, A. W	Cincinnati & White Water Valley	Harrison, Ohio.
BROWN, C. H	Late Delaware, Lackawanna & Western	Utica, N. Y.
COOPER, W. E		Dunkirk, N. Y.

NAME.	ROAD.	ADDRESS.
CHAPMAN, N. E.	Cleveland & Pittsburgh	Cleveland, Ohio.
CUMMINGS, S. M.	Pittsburgh, Fort Wayne & Chicago	Allegheny, Pa.
COOLIDGE, G. A.	Fitchburg	Charlestown, Mass.
CLARK, D.	Lehigh Valley	Hazleton, Pa.
CHURCH, FOSTER	Troy & Boston	Troy, N. Y.
CUSHING, GEORGE		Chicago, Ill.
CURTIS, ROBERT	Pittsburgh, Cincinnati & St. Louis	Columbus, Ohio.
CLARK, PETER	Northern of Canada	Toronto, Canada.
CASSCADDIN, R. O.	Chicago, Rock Island & Pacific	Trenton, Mo.
DeCLERCQ, A. H.	International & Great Northern	Hearne, Texas.
DEVINE, J. F.	Wilmington & Weldon	Wilmington, N. C.
DRIPPES, ISAAC	Pennsylvania	West Philadelphia, Pa.
EASTMAN, C. L.	Concord	Concord, N. H.
EASTMAN, J. U.	Nashville & Chattanooga	Nashville, Tenn.
FRY, HOWARD	Philadelphia & Erie	Williamsport, Pa.
FLYNN, J. H.	Western & Atlantic	Atlanta, Ga,
FULLER, WILLIAM	Atlantic & Great Western	Meadville, Pa.
GRAHAM, CHARLES	Lackawanna & Bloomsburg	Kingston, Pa.
GLASS, G. W.	Allegheny Valley	Pittsburgh, Pa.
GARFIELD, E.	Hartford, Providence & Fishkill	Hartford, Conn.
GARRETT, H. D.	Pennsylvania	West Philadelphia, Pa.
GRIGGS, ALBERT	Worcester & Nashua	Worcester, Mass.
GRANGER, W. E.		
GOULD, F.		Middletown, N. Y.
HAYES, S. J.	Illinois Central	Chicago, Ill.
HILL, E. O.	Erie	New York City.
HAM, C. T.	Buffalo Steam Gauge Co.	Buffalo, N. Y.
HUDSON, W. S.	Rogers Locomotive Works	Paterson, N. J.
HULL, A. S.	Cumberland Valley	Chambersburg, Pa.
HEALY, B. W.	Rhode Island Locomotive Works	Providence, R. I.
HIBBERD, A. W.	Jefferson City Iron Works	Jefferson City, Mo.
HOLLISTER, C. W.	Valley	Hartford, Conn.
HUBBARD, J. G.	Erie	Buffalo, N. Y.
HODGMAN, S. A.	Philadelphia, Wilmington & Baltimore	Wilmington, Del.
HANGLIN, J. A.	Texas Pacific	Marshall, Texas.
KELLY, JOSEPH	Providence and Worcester	Providence, R. I.
KERR, THOMAS	Camden & Amboy	Bordentown, N. J.
KEELER, SANFORD	Flint & Pere Marquette	East Saginaw, Mich.
KIDDER, B. H.		Buffalo, N. Y.
LOSEE, T. V.	Indianapolis, Bloomington & Western	Urbana, Ill.
LAUDER, J. N.	Northern New Hampshire	Concord, N. H.
LEWIS, C. M.	Northern Central	Baltimore, Md.
LINGLE, THOMAS	Chesapeake & Ohio	Richmond, Va.
LANNON, WILLIAM	Western Maryland	Union Bridge, Md.
LEACH, H. L.	Hinkley Locomotive Works	Boston, Mass.

NAME.	ROAD.	ADDRESS.
MOORE, S.	Pittsburgh, Fort Wayne & Chicago	Allegheny, Pa.
MORSE, G. F.	Portland Locomotive Works	Portland, Maine.
NOYES, WARREN	Great Western	Gorham Station, N. H.
OSBORNE, EZRA	Grant Locomotive Works	Paterson, N. J.
PIERCE, E.	Pittsburgh, Cincinnati & St. Louis	Dennison, Ohio.
PHILBRICK, S. M.	Leavenworth, Lawrence & Galveston	Lawrence, Kansas.
PERRIN, P. J.	Taunton Locomotive Works	Taunton, Mass.
PEDDLE, C. R.	Terre Haute & Indianapolis	Terre Haute, Ind.
PRESCOTT, A. J.	Catawissa	Catawissa, Pa.
PHILBRICK, J. W.	Maine Central	Waterville, Maine.
RICHARDS, GEORGE	Boston & Providence	Boston, Mass.
ROBINSON, W. A.	Great Western of Canada	Hamilton, Canada.
SETCHEL, J. H.	Little Miami	Cincinnati, Ohio.
SMITH, W. T.	Philadelphia & Erie	Erie, Pa.
SEDGLEY, JAMES	Lake Shore & Michigan Southern	Cleveland, Ohio.
STRONG, W. M.	New York & Harlem	New York City.
SANBORN, A. J.	Indianapolis & St. Louis	Mattoon, Ill.
STEARNS, W. H.	Connecticut River	Springfield, Conn.
STERK, F.	Virginia & Tennessee	Lynchburg, Va.
SMITH, W. B.	South Carolina	Charleston, S. C.
SPRAGUE, H. N.	Porter, Bell & Co.	Pittsburgh, Pa.
THOMPSON, JOHN	Eastern	East Boston, Mass.
THOMPSON, JOHN.	Pittsburgh, Fort Wayne & Chicago	Crestline, Ohio.
TULL, C. H.	North Louisiana & Texas	Monroe, La.
TAYLOR, J. K.	Old Colony & Newport	Boston, Mass.
TURREFF, W. F.	Lake Shore & Tuscarawas Valley	Black River, Ohio.
VAN VETCHEN, J.	Erie	Port Jervis, N. Y.
WARREN, B.	St. Louis, Alton & Terre Haute	St. Louis, Mo.
WALLACE, H. S.	Columbus & Hocking Valley	Columbus, Ohio.
WOODCOCK, W.	Central of New Jersey	Elizabethport, N. J.
WELLS, R.	Jeffersonville, Madison & Indianapolis	Jeffersonville, Ind.
WADE, R. D.	North Carolina	Company Shops, N. C.
WHITE, J. L.	Evansville & Crawfordsville	Evansville, Ind.
WOOD, M. P.		New York City.
WHITE, PHILIP	Cleveland & Pittsburgh	Wellsville, Ohio.
YOUNG, L. S.	Cleveland, Columbus, Cincinnati & Ind.	Cleveland, Ohio.

ASSOCIATE MEMBERS.

NAME.	ROAD.	ADDRESS.
BEMENT, W. B		Philadelphia, Pa.
FORNEY, M. N	Railroad Gazette	New York City.
MILES, F. B		Philadelphia, Pa.
MORTEN, HENRY		Hoboken, N. J.
NOTT, GORDON H		Boston, Mass.
THURSTON, R. H		Hoboken, N. J.
SELLERS, COLEMAN		Philadelphia, Pa.
WHEELOCK, JEROME		Worcester, Mass.

The President requested the Secretary to read the following Article of the Constitution relative to membership:

ARTICLE IV.

SECTION 1. The following persons may become members of the Association by signing the Constitution, or authorizing the President or Secretary of the Association to sign for them, and paying the initiation fee of one dollar: Any person having charge of the Mechanical Department of a Railway, known as "Superintendents," or "Master Mechanics," or "General Foremen," the names of the latter being presented by their superior officers for membership; also two Mechanical Engineers or the representative of each Locomotive Establishment in America.

SEC. 2. Civil and Mechanical Engineers, and others whose qualifications and experience may be valuable to the Association, may become Associate Members by being recommended by three active members. Their names shall then be referred to a committee, which shall report to the Association on their fitness for such membership. Applicants to be elected by ballot at any regular meeting of the Association, and five dissenting votes shall reject. The number of Associate Members shall not exceed twenty. Associate Members shall be entitled to all the privileges of active members except that of voting.

THE PRESIDENT—Opportunity is now offered to those who are eligible to membership to sign the Constitution.

NEW MEMBERS.

NAME.	ROAD.	ADDRESS.
BREWER, S. E	New York, New Haven & Hartford	Hartford, Conn.
BLACKBURN, V	Erie	Jersey City, N. J.
CHAPMAN, J. W	Erie	Hornellsville, N. Y.
DRIPP, W. A	New York & Oswego Midland	Philadelphia, Pa.
FOSTER, W. A	Fitchburg, V. & M. Division	Fitchburg, Mass.
HILL, RUFUS	Camden & Atlantic	Camden, N J.
HAGGETT, J. C	Dunkirk, Allegheny Valley & Pittsburgh	Dunkirk, N. Y.
HARDING, B. R	Raleigh & Gaston	Raleigh, N. C.
LA SEUR, W	Flushing & North Shore	College Point, L. I.
McDOUGAL, R	Mobile & Ohio	Whistler, Ala.
NOBLE, L. C	Houston & Texas Central	Houston, Texas.
PENDLETON, M. M	Seaboard & Roanake	Portsmouth, Va.
STRODE, JAMES	E. & C. Division Northern Central	Elmira, N. Y.
SIMPSON, C. G. C	Montreal, O, & W	Montreal, Canada.
WILDER, F. M	Erie	Buffalo, N. Y.
WALLACE, ROBERT	Erie	Susquehanna, Pa.

The President then delivered his annual address:

PRESIDENT'S ADDRESS.

Gentlemen of the Association:

Let us rejoice in this reunion! Again it is our happiness to re-echo those words of welcome which for eight consecutive years have sprung spontaneously from our hearts and lips. I congratulate you upon this large gathering of our fraternity; I congratulate you on the prosperity, harmony, and usefulness of our Association.

Gentlemen, without confining myself to any particular department of railway management, I have taken the liberty, in past years, so far as I have been able, to review with you the prominent features in the general condition of the railways throughout the country. I have not sought to be an alarmist nor a prophet of ill, yet I could not avoid pointing out to you what seemed to me the tendency, from the gross errors and extravagances which had obtained so strong a hold upon our railway economy. The results which you and I then foresaid have followed, and we are in the midst of a widespread rail-

way bankruptcy. I am not about to discuss it; this is not an occasion to be given up to painful subjects, but I should fail in *my* duty, gentlemen, and you will fail in what the railway interests of the country have a right to expect from you, if we do not attempt to show how the equipment of railways can be so reformed as to aid in restoring this great industry to a solvent condition.

Gentlemen, this railway bankruptcy has given rise to various expedients for overcoming it. Among other remedies, "narrow-gauge railways" have been recommended as capable of so much cheaper operation that their adoption would work a cure. I refer to this, not for the purpose of discussing the question of gauge, but to call your attention to the fact that where the narrow gauge has been adopted the great practical effect has been to materially reduce the weight of the rolling stock.

Here, gentlemen, it is well we should pause for reflection; here we are touched in our own department of railway economy; here we are affected where we alone are concerned, and where we have the whole responsibility. If a narrow-gauge railway can be operated at materially less expense than one of the ordinary gauge, chiefly because the rolling stock in use upon it is lighter, or, to speak more correctly, there is less dead weight hauled upon the narrow gauge in proportion to the paying weight, is there not a remedy at once to be applied to reduce the cost of doing business on railways of the ordinary gauge by reducing the weight of the rolling stock?

Gentlemen, during the last twenty years railways of the ordinary gauge have not changed in their superstructure, in their bridges, or in their iron, but the rolling stock in use upon them has increased in weight from fifty to one hundred per cent., and the usual load for a freight car has increased fifty per cent. The same bridge and the same iron, and yet an enormous increase in the weight which is constantly bearing down to crush that iron and those bridges. Gentlemen, can any thing be more obvious than that if the proper proportions formerly existed between the superstructure, the iron, and the bridges, and the weight of the rolling stock, those proportions are now entirely out of balance?

If a locomotive that weighed twenty-two tons, a freight car that carried eight tons, and a passenger car that weighed fifteen tons, were suitable to the ordinary gauge of railways twenty years ago,

how is it that, without changing the roads, we are now operating on them locomotives weighing thirty-three tons and upward, freight cars loading twelve tons and upward, and passenger cars varying from twenty to thirty-five tons?

I believe, gentlemen, that these are essentially the facts of the case. I believe they have had a material influence in producing the present railway bankruptcy, and it seems to one that it does not speak well for our influence as Master Mechanics that we have not been able to do more with railway managers in preventing the use of rolling stock of such enormous weight.

At this meeting, and as an Association, it is our duty to do all in our power to correct this great evil. We must show that a change of gauge is not what is required, but a change in the weight of the rolling stock.

The present gauge, the gauge of Stevenson, will answer for all main lines of railway if the dead weight of rolling stock is not so out of proportion to the paying weight as to be a burden upon the commerce of the country by materially affecting the earnings of its railways.

The reports presented at the last Annual Convention were well prepared, for which the committees deserve great credit. Each member should render such assistance as he can to the committees by answering their circulars early, so as to give them ample time to prepare their reports before our annual meetings.

After the reports have been read in open convention and are ready for discussion, all should take an active part and enter into the discussion, so that we may arrive at important and valuable facts that can be reached in no other way. I trust that no member of this Association will hesitate to give us the benefit of his experience upon any topic that may come before this Convention, for it is only by a free interchange of thoughts and views, openly expressed in a free and candid discussion, that we can arrive at the object of our Association.

Gentlemen, the question is often asked why we, as an Association, do not arrive at definite conclusions. This question should be carefully considered. If we meet each year in Convention, have the reports of the committees and fully discuss them, I doubt if there is a necessity of any definite action as a Convention. We can judge

from the reports and discussions as to which is the best material and which the best manner of construction.

At our Ffth Annual Meeting the Committee on "Computing Mileage" recommended a uniform system of keeping "mileage" and "repair" accounts which was was adopted.

It is to be hoped that all who publish their reports will follow their recommendation, so that as we compare reports we can do so understandingly.

Gentlemen, we are under many obligations to the Railway Gazette and other mechanical papers of the country, and the press generally, for printing our circulars, reports, and other matter.

Your Secretary has performed his duties the past year with the same skill and correctness for which he is characteristic. The duties of that office are increasing each year. The Committee on Assessment should commence their work early in the session, and each member present should settle with the Committee, thereby saving the great trouble of sending through the mail.

Gentlemen, the city of New York is fast becoming the commercial center of the civilized world. In every age the commercial capital has become the seat of the mechanical arts; there they have found their greatest development and their largest usefulness. The commercial capital of this country, the destined center of the commerce of the world in this age, makes no exception to that law of the past. This period far surpasses in mechanical devices applied to commerce all that have preceded it. The infancy of the present application of the steam engine to navigation was here—Robert Fulton, after having had his proposals rejected by "Napoleon the Great," launched his first steamboat on the Hudson river. From that birth have sprung the wonderful application of steam to commerce, by land and by water, without using and enjoying which we can not move to or from New York.

New York steamers now vex every ocean and every sea, and New York capital causes a thousand locomotives, traversing the entire continent, to visit every city, aye! every hamlet, from beyond the lakes to the gulf; from every portion of the Atlantic shores to the slopes of the Pacific Ocean.

Gentlemen, I thank you for your attention while I have been

making these crude remarks; I thank you for the many acts of kindness shown me since the formation of this Association.

I now invite you to enter upon the business of the Convention.

THE PRESIDENT—The next business in order is the report of the Secretary.

SECRETARY'S REPORT.

To the American Railway Master Mechanics' Association:

GENTLEMEN—I herewith submit for your information a detailed statement of the condition of finances, membership, and such other matters as have seemed of sufficient importance to justify a brief mention, and coming within the range of the duties of your Secretary.

MEMBERSHIP.

Since last report six members have resigned and thirty-seven have joined the Association; of these, thirty became members at the Seventh Annual Convention, and seven since that time by authorizing the Secretary to sign the Constitution, as provided for in Section 1 of Article IV.

The names of sixteen members, being two years in arrears for annual dues, will hereafter be stricken from the roll and the parties duly notified of the same. The total number of full members, after excluding delinquents, is 224; Associate members, 12.

Fifteen hundred of the Seventh Annual Report, containing three hundred and twenty-seven pages, have been printed by the same parties and at the same rate as the previous year, but there being thirty-nine per cent. more matter to be printed, the total cost has been correspondingly increased, as you will see by the report of your Treasurer.

Of the above number there has been sent:

To members	975
To Master Mechanics, not members	150
To Superintendents	75
To various parties on application	15
Total	1,215

FINANCIAL.

The expense attending the sending out of reports and circulars has been as follows:

Postage on 954 copies sent by mail	$66 78
Postage on miscellaneous reports	1 47
Postage on 3,750 circulars	21 75
Miscellaneous postage and money orders	31 05
Total	$121 05

The receipts of the Association have been, from

Assessment	$2,030 00
Initiation	36 00
W. W. Evans, donation	10 00
Unknown, donation	5 00
By direction of the General Supervisory Committee $1.00 per copy has been charged for reports sent to parties having no connection with railroads or the Association, and there has been realized from this source	17 14
Total receipts	$2,098 14

Due on certified unpaid bills	$313 08
Due the Associations from members	680 00

The principal and interest of the Boston Fund, amounting to $3,620, is on deposit in the Lafayette Bank of Cincinnati, in trust for and subject to the order of the Association or its Trustees.

There is yet on hand in the Secretary's office, of the

First and Second Annual Reports	684	copies.
Third Annual Report	151	"
Fourth "	54	"
Fifth "	287	"
Sixth "	109	"
Seventh "	273	"

In addition to the above there are seven hundred small envelopes and three thousand engraved letter heads. The Association is also the owner of a dynamometer, presented by Messrs. Prosser & Son, and also a choice volume of engravings, presented by Gustavus

Weissenborn of this city, which are by direction of the Association in the custody of the General Supervisory Committee.

In this connection permit me to call your attention to the fact that the cost of sending out our annual reports the ensuing year will be considerably in excess of previous years, if sent by mail, on account of the postage on such matter being increased one hundred per cent., and would respectfully suggest that those members who can have their reports sent by express free of charge, as many of them can do, should notify the Secretary of the fact that this amount may be saved to the Association.

Very respectfully,

J. H. SETCHEL,

Secretary.

On motion, the report of the Secretary was received.

THE PRESIDENT—The report of your Treasurer is in the hands of the Secretary, and is the next business in order.

TREASURER'S REPORT.

May 11th, 1875.

S. J. HAYES, Treasurer, in account with

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

1874.		Dr.	1874.		Cr.
May 12	To Balance Fund	$298 38	May 15	By J. H. Setchel, Secretary, Voucher 1,	$500 00
May 15	" Cash from Secretary	1,155 00	May 15	" Wilstach, Baldwin & Co., " 2,	448 50
Sept'r 30	" " "	200 00	May 21	" Ely & Burnham, " 3,	258 25
1875.			Dec'r 16	" Wilstach, Baldwin & Co., " 4,	400 00
Jan'y 13	" " "	104 75	1875.		
Jan'y 28	" " "	70 00	Jan'y 13	" J. H. Setchel, Secretary, " 5,	104 75
Feb'y 27	" " "	40 00	Mar. 20	" Wilstach, Baldwin & Co., " 6,	150 00
Mar. 29	" " "	20 00	April 29	" " " " " 7,	270 00
April 29	" " "	270 00	May 4	" S. J. Hayes, " 8,	3 50
May 10	" Wilstach, Baldwin & Co.	222 00	May 10	" Wilstach, Baldwin & Co., " 9,	222 00
May 10	" J. H. Setchel	16 35	May 10	" J. H. Setchel, " 10,	16 35
				" Balance on hand	23 13
		$2,396 48			$2,396 48

Approved by

Balance due printer, $313.08.

J. W. PHILBRICK,
THOMAS KERR,
W. McALLISTER, } *Finance Committee.*

Respectfully,

S. J. HAYES, *Treasurer.*

On motion, the report of the Treasurer was received.

Mr. WOODCOCK, Central Railroad of New Jersey—I move that a committee be appointed by the Chair to make an assessment to meet the expenses of this Association for the current year.

The motion was seconded and agreed to.

The Chair appointed as such committee, Messrs. Woodcock, Taylor, and Sanborn.

THE PRESIDENT—The Committee on Finance, consisting of Messrs. Philbrick, Kerr, and McAllister, will please examine the accounts of the Secretary and Treasurer, and report to the Convention during the session. The Committee on Assessment is ready to report.

Mr. WOODCOCK, Central Railroad of New Jersey—The Committee on Assessment recommend that ten dollars be levied upon each member of the Association for the purpose of defraying the expenses of the current year.

On motion, the recommendation was adopted.

Mr. ROBINSON, Great Western Railroad of Canada—I move that the Committee be directed to collect the assessment.

Carried.

THE PRESIDENT—The next regular business is the report of the Committee, appointed at the last session, on "The Best Material, Construction, Operation, and Management of Locomotive Boilers." The Committee consists of Messrs. Boon, Jackman, and Cushing. Their report is in the hands of the Secretary.

Report of Committee on the Operation and Management of Locomotive Boilers, Including the Purification of Water.

To the American Railway Master Mechanics' Association:

GENTLEMEN—Your Committee, appointed on "The Best Material, Construction, Operation, and Management of Locomotive Boilers," beg leave to submit the following:

From replies to your Committee's Circular, we are led to believe that the material in general use for locomotive boilers and fire boxes are steel and iron. We have reports from two hundred boilers, the outside shell and waist of which are steel. All who are using them report favorably. No defects have been discovered after a service of six years. Have also a report of an iron boiler with steel throat sheet. This boiler is also doing well. Some gentlemen object to steel on account of the first cost, claiming that the difference in cost of steel over good iron is greater than its utility over iron. We also

have reports of some two hundred boilers, the outside sheets of which are iron. These are all reported as doing well. Steel and iron are being used for fire boxes. Your Committee have no report of any copper fire boxes. Steel fire boxes in service, with wood for fuel, are giving general satisfaction. All who are using them are well pleased with the result. The steel fire box, with bituminous coal as fuel, is not giving so general satisfaction. Complaints are made that the side sheets will crack after a service of from six months to two and three years. These cracks invariably take place in the side sheets. (Have no reports of any other sheets cracking.) The crack starts about seven inches from the grate bars, in the center of the length of the fire box, and extends vertically from ten to thirty inches long; sometimes straight between the stay bolts; at others, the cracks are zigzag from stay bolt to stay bolt, and opening about one-sixteenth of an inch in the center of the crack. The fracture is sometimes accompanied with a loud report; at other times no report is made, and the trouble is discovered by the water running out. Some have cracked when the boiler was being filled with cold water; some when the boiler had been standing for twenty-four hours with the same water as when the engine came in from a trip—and no disturbing cause whatever. Others have cracked on the left hand side when workmen were riveting up stay bolt on right side of fire box.

We have a report of a steel fire box with iron crown sheet, and of fire boxes with copper side sheets. The gentleman does not state whether the remainder of the fire box is iron or steel. These fire boxes are reported as doing well. The iron fire box is also objected to on account of cracking and blistering. The blistering is caused by imperfect welding of the iron, and will take place with either wood or coal for fuel, but more rapidly with coal. Your Committee have no report of fire boxes in which anthracite coal is used as fuel.

From information gathered from answers to circulars, and their own experience, your Committee are of the opinion that good homogeneous steel, that will not harden, is the best material for boilers and fire boxes. The first cost is the only objection urged against its use in outside shells. This can be offset by the lighter boiler. Steel has a tensile strength of nearly twenty per cent. more than iron, and

your Committee believe that steel sheets of five-sixteenths of an inch thickness can be used with safety in boilers of forty-eight inches diameter and under, where three-eighths of an inch iron sheets would have to be used. This difference in weight would make the cost of the two materials very near the same, with the additional advantage of the reduced weight of engine. Steel boilers have not been in use long enough to judge as to the wear of the material; but we believe that, on account of the metal being more dense than iron, the corroding, or grooving, so fatal to an iron boiler, will be more gradual, and the life of the boiler longer.

Your Committee have lately examined the inside of a steel boiler after three years' service. There were no signs of corroding; the sheets looked as well as when first put in. Steel and iron are now used for wood-burning fire boxes. Steel is giving the best results, as lighter sheets can be used, and the metal will not blister. This is the defect in most of the iron used in fire boxes. When a good quality of iron is used, that will not blister, a fire box will last from eight to twelve years with wood. In using bituminous coal for fuel, copper, steel, and iron are used. Copper will not crack. The objection to its use is the wearing away or abrasion of the copper. This is a mechanical action caused by the fine particles of coal and cinder rubbing against the copper, either by the draft, throwing in of coal, or stirring up the fire. This will, in a short time, reduce the copper to a thinness that would be dangerous. The worst feature of this is, it can not be detected without drilling holes through. As "the sheet between the stay bolts becomes worn away, the pressure forces it out nearly to the line, or plane, originally occupied when new—to the eye it has the appearance of being intact." From the information your Committee have been able to obtain, the life of a copper fire box is from three to five years. There are instances where they have been destroyed in eight months; and again, where one has lasted eight years. The objections to iron fire boxes are: the difficulty in obtaining iron that will not blister, and that the iron becomes "burnt out," very brittle, and will crack. Three years is about the average life of an iron fire box burning coal.

The objection to steel fire boxes is, that they will crack. This is their only defect. Their advantages are: sheets can be used thin enough to transmit the heat readily from the fire to the water, with

a tensile strength sufficient to stand the pressure; a surface of such density as to resist the abrasion and wear from the coal, and by using thinner, therefore lighter sheets, reduce the weight of the engine.

Your Committee have a record of forty-one steel fire boxes, about the first put in in this country. The average of the three highest was nine years and six months; average of the three lowest, four years and four months; average of the forty-one engines, six years and four months. We have also examined some fire boxes made of all quarter inch steel, excepting the tube sheet, which have been in service four years and one month, and are now good without a patch on them. Have also a record of eighty steel fire boxes, the oldest eight years old, six sheets of the whole number having cracked. Different causes have been assigned for the cracking of the sheets, among them unequal expansion and contraction, running cold water into the boiler, want of uniformity in the steel, and from the steel having an affinity to sulphur, and gradually absorbing it, until the nature of the steel becomes changed, and the fracture takes place. Your Committee are of the opinion that one of the last two is the cause of the trouble. If it was the expansion and contraction, all should crack; but of the same class of engines, and same make of steel, one will run, and the fire box remain good, while the other will crack.

Your Committee believe that the metal, as manufactured, is not uniform, They also believe that some chemical action not fully understood takes place between the gases and the steel when the coal is being consumed in the fire box. Your Committee are of the opinion that the manufacturers of boiler steel should take this matter in hand, and produce a uniform metal; also, to investigate what changes, if any, take place in the metal after being exposed to a bituminous coal fire. They all claim to employ expert chemists about their works, and should do this for their own interests.

Iron tubes are used almost exclusively on coal-burning engines. In sections of the country where the water is bad they have to be taken out in from eight to thirty months. The action of the coal is to wear off the beading and start them to leaking.

In construction of boilers there has been nothing new since our

last meeting. But few new locomotives have been built during the past year. The general practice is to use three-eighths inch iron or steel for outside sheets of boiler, five sixteenths inch steel or iron for fire boxes, and from three-eighths to one-half inch for tube sheets; water space around the fire box from two and a half to three and a half inches inside, and from two and three-fourths to four inches in front of fire box; at straight seams eleven-sixteenths inch rivets are generally used, one and three-fourths inches from center to center. All longitudinal seams are being double riveted: centers of the two lines of rivets, one and one-eighth inches; center to center of rivets on same line, two and three fourths inches; center to center, from one line to the other (or zigzag) one and three-fourths inches; stay bolts, seven-eighths of an inch, four in from center to center. The size of rivets, stay bolts, braces, and their position in the boiler, should be governed by the size of boiler and thickness of sheets used. There are rules given to determine their sizes. Your Committee are of the opinion that, for fire boxes, thin sheets give the best results. Sides and back of one-quarter inch steel, crown sheets five-sixteenths and tube sheets three-eighths of an inch of steel give good results. Tube sheets of seven-sixteenths inch iron, and the remainder of the fire box five-sixteenths inch iron, have also been reported as giving good results, until the iron became blistered.

Your Committee believe that one-fourth inch steel is strong enough for the side sheets of fire boxes, and also believe it less liable to crack than five-sixteenths or three eighths inch. They have found it more pliable, and more easily straightened, when sagged down from mud collecting on it, than iron sheets five-sixteenths of an inch thick. It will not crack so readily from the crown bar rivets, when overheated from deposits of sediment.

Your Committee believe that the water spaces between the fire box and outside shell, for coal burning, should never be less than three inches, and would recommend three and one-half inches. They are of the opinion that, in many old boilers which have been changed from wood to coal burners, with the original water space of two and one-half and two and three-fourths inches, the destruction of the fire box, and trouble of keeping in repair, is caused by the sheets being burned—the water being driven out of the water space with

the intense heat. Very good results are obtained by narrowing the fire-box from bottom to top, and thereby increasing the water space, giving a better circulation.

Large sheets in boilers are being generally used, and are giving good satisfaction. It is the opinion of all that no advantage is derived from a large smoke box, but that the steaming of boilers have been improved by reducing their size. In this your Committee agree, as they have found in practice that, with a large smoke box, the nozzels had to be contracted to an injurious extent to produce the necessary draft. When the area of the smoke box was reduced, larger nozzels could be used, and the working of the engine improved.

Pressure gauges are universally used. Water gauges are coming into more general use. Your Committee have no report of any new boiler attachments.

Injectors for feeding boilers are again being used. They were for a time discarded; but as coal burning becomes more general, they are being applied in addition to one pump.

There is a difference of opinion in regard to the braces from frame to boiler. In some the bracing consists of angle iron riveted to the under side of waist, connecting with a one-half inch iron plate to a brace running from frame to frame. In some plans the guide yoke is carried over the frames and the plate bolted to that. Another plan is to rivet braces to the boiler, the heel under the waist, near the center. Your Committee believe that both the above plans are objectionable, and believe that no brace or fastening of any kind should be in the bottom of the boiler. If riveted or bolted, corrosion is sure to take place about the heads, and the expansion and contraction will break the sheet. It is but a question of time when this will take place. All braces from frame to boiler should be fastened to boiler at the center line on side of boiler, and the brace made light, so that the expansion and contraction of the boiler would spring the brace, and have no effect on the boiler sheets. The least possible number of braces from frame to boiler the better. We believe, in most engines, one brace on waist at each side is ample.

One hundred and twenty pounds of steam to the square inch is considered a safe working pressure with a good boiler. On some roads one hundred and thirty pounds is the maximum pressure.

The life of a locomotive boiler depends on the quality of the material the boiler was made of, the purity of the water used in it, plan of boiler, pressure of steam, and care taken of boiler while in service. Your Committee believe that, from the time a boiler goes into service, the metal of which it is made commences to deteriorate, and continues to do so as long as it remains a boiler. How rapid this is, or when it has continued until the boiler becomes unsafe, has not been determined. One of your Committee has, in less than seven years, broken up fifty-four locomotive boilers, all of iron. Some of them had been made of the very best Pennsylvania charcoal iron; yet, after twenty years' service, they broke like very poor cast iron, the fracture showing a very white, fine grain. The first defects to show are generally on the bottom of waist. At the seam of front tube sheet the iron will be corroded or eaten through. Should there be a brace riveted or bolted on the bottom, defects will show about the heads of the rivets or bolts. Sometimes the sheets are pitted or corroded out in spots from one quarter to two and three inches in diameter. These defects show in from three to five years after a new boiler goes into service, and increase with the age of the boiler. Have known boilers to be condemned for this cause (corroding) after seven years' service.

Your Committee believe twelve years to be as long as it is profitable to use a locomotive boiler, and where the water is bad they will not be safe over ten years. Your Committee are well aware that many persons will differ from this opinion, and claim that boilers will run for twenty years and over. The fact that they do so does not prove them to be safe boilers.

Tubes should be removed for examining the boiler every three years. On roads with bad water the tubes are removed more frequently; on some roads they have to be taken out every twelve months. The only sure way to know the condition of a boiler is to remove all the tubes, clean all the incrustation out, and then carefully inspect it. There is no certainty in testing with pressure, as the boiler may stand the pressure and yet be defective, and may develop and increase defects already in existence. Your Committee know of an instance where a boiler stood a hydraulic pressure of one hundred and fifty pounds to the square inch, and yet exploded

in less than three months after the pressure was applied, with one hundred and ten pounds pressure of steam.

JAS. M. BOON, *Pittsburgh, Ft. Wayne & Chicago,*
J. A. JACKMAN, *Chicago, Alton & St. Louis,*
GEO. W. CUSHING, *late Toledo, Wabash & Western,* } *Committee.*

On motion, the report was accepted.

THE PRESIDENT—Gentlemen, is it your pleasure that we now enter upon the discussion of the report? We have usually discussed each report immediately after its being read, but by some it has been thought better to defer it, and appoint certain members to open the discussion on the various subjects, and make them a special order for a certain hour.

Mr. LAUDER, Northern New Hampshire Railroad—Mr. President, in order to bring the matter fairly before the Convention, it seems to me necessary to make some motion, and as there is no question before us, I move that the discussion of this subject take place at the present time. If any member thinks it better to postpone it, let him vote against the motion.

Carried.

THE PRESIDENT—The subject is now open for discussion.

Mr. CASCADDIN, Chicago, Rock Island & Pacific Railroad—I have eighteen locomotives under my charge which have steel boilers; I have had them in active service for four years, and in all that time but one has cracked. That was in the crown sheet, outside, close to a double row of rivets, and parallel to the center of the boiler. I am not, however, prepared to say that I would recommend the use of steel boilers. I state this for the benefit of those who may want to know what my experience has been in the use of these engines. They have run from twenty-five to thirty thousand miles per year during all the time that they have been in use, and I have never had to patch but the one.

Mr. FRY, Philadelphia & Erie Railroad—It seems to me that the discussion of this subject should occupy a considerable portion of our time, since it is one of the most important that is likely to come before us. A remark made by Mr. Cascaddin is deserving of careful consideration. As the report of the Committee leaves the subject of steel in the construction of boilers, the world would be led to assume that it was a very unreliable material. From the reading of that report no one could tell, if they used steel for boilers, whether it might or not fly to pieces like a plate of glass, but would infer that the fire box was always liable to crack. The first speaker, however, stated that of eighteen steel boilers he has only known one sheet to crack in four years, and the place where that cracked is one where boilers are very liable to rupture of whatever material they may be composed. I think that it is important for us to find whether any other Master Mechanics have had similar experience; and if the fact should be developed that certain of us

can use steel without any bad results, without any special liability to crack, or with no greater liability than can be accounted for by the use of defective material, and that this liability to crack is not so serious as to make the whole material unreliable, we should be led inquire whether there is any difference in the treatment of steel by those Master Mechanics that are successful in its use, and the treatment of those who find it to crack. It may be that the different results are due to the difference in the fuel used, or to a difference in the construction of the boiler. There was an article in the Railroad Gazette recently upon the use of steel in various structures, and especially in boilers. I think it stated that a discussion upon such subjects had taken place in England, and very great fears were there expressed as to the reliability of steel when so used. I made a visit to England in the fall of last year, and I found a very great interest manifested there in respect to the use of steel in America. I may say in this connection that a Master Mechanic who formerly held a position in this country, had been taken to England, and placed in charge of one of the largest works there, principally because he had had experience in the use of steel for locomotive boilers. In these large steel works he showed me a great many boilers that were being built of steel. I was struck by the curious fact that they were using steel for the outside sheets and seemed afraid to use it for fire boxes, while we in this country use it principally for fire boxes, and are nervous about putting it in outside sheets. Many inquiries were addressed to me as to whether we found steel reliable. I could only speak from my own experience which was somewhat limited; and I thought how useful it would be if I could refer to some discussion before our Convention, in which a large number of Master Mechanics had participated by giving their experince, for then, I might have been able to give valuable facts. I make these remarks, hoping that it will draw out some of the members who have had experience in the use of steel for a number of years, so that we may learn whether any of us have been using steel successfully, and have no fear of any disastrous results from its continued use.

Mr. BROOKS, Brooks Locomotive Works—Perhaps it would be well for me to make a few remarks in this connection, as I commenced the use of steel for locomotive fire boxes in 1860. I made a visit to the Great Western Shops in that year, and Mr. Eaton, who then had charge, was at that time engaged in constructing a boiler entirely of steel. I think at that time, there had been no steel used this side of the lakes; in fact, I think at that time there had been no steel used in the United States for fire boxes. Of course I felt a little anxious in regard to the experiment. I was about to construct six locomotives, and decided, after careful consideration, upon the use of steel five-sixteenths of an inch thick for side, back, front and crown sheets. The boiler was constructed I think, by Mr. Perrin of the Taunton Locomotive Works. We had some correspondence on the subject. My own opinion then was, that it would be unsafe to use it unless it was thoroughly annealed; that is, unless the sheet after being flanged should be put in a uniform slow wood fire,

brought up very slowly to a red heat, and kept there long enough to allow the strains that had been thrown into the sheet by the process of flanging to gradually assert themselves; for I believe that those strains are one of the principal reasons of the cracking of the sheets. One of those fire boxes that were constructed in the fall of 1860 was sent to the Brooks Locomotive Works in 1868, when Mr. Brown had charge of the machinery department of the Erie Railroad, for a new boiler, the boiler having been used continuously on very severe and heavy freight service, and the original fire box, put in in 1860, was continued I think until 1873. It had been in heavy freight service for twelve years, and had probably run on an average thirty-six thousand miles per year; I have no doubt of that, because of my own knowledge it has run as high as four thousand miles per month. Neither of those six locomotives constructed in 1860 and 1861 had their fire boxes removed until after 1870. Two of the boilers were constructed by Mr. Perrin of Taunton Works, and four at Páterson; they all had fire boxes and crown sheets of five-sixteenths of an inch steel. After we had experimented with those engines and with many others having steel fire boxes upon the Erie Road, we adopted to a large extent the use of one-fourth inch steel for all the sheets of fire boxes, excepting the flue sheet, which was made of one-half inch steel. The flue sheets of the fire boxes that I referred to were also one-half inch steel instead of five-sixteenths of an inch. I think that I can safely assert that no road in the country has had better success in the use of steel fire boxes than the Erie; and I attribute that success in a great degree to the fact that the sheets of the fire boxes are thoroughly annealed before they are riveted. The great difficulty with many in the use of steel arises from the fact that the sheet is put into the fire box without giving it an opportunity to relieve itself from the strains to which it has been subjected in in the operation of flanging. It takes but a moment's reflection to show that the operation of flanging will throw very heavy strains within the structure of the sheet itself; and if you confine it on its outline, and especially if you confine it by stay bolts, it is impossible for it to be used without cracking.

Mr. Setchel, Little Miami Railroad—I would like to interrupt the gentleman by asking a question. He will notice that by the experience of the Master Mechanics, as given in their reports to the Committee, the only cases of cracking were in the side sheets; and there is no flanging in them, even if they were not annealed, to make the unequal strain that he speaks of.

Mr. Brooks, Brooks Locomotive Works—But they are punched if they are not flanged; and punching throws the strain around the rivet holes.

Mr. Setchel, Little Miami Railroad—But the cracking occurs only in the center of the side sheets and not around the rivet holes.

Mr. Brooks, Brooks Locomotive Works—The side sheets are not only punched, but they are rolled. They are not straight sheets, and I take it that every manipulation that you put into the structure of metal has a ten-

dency to strain it. If you strike a single blow upon a plate or bar, the effect of that blow is received within the metal; and if you confine the effect by holding it at one point there is no possible chance for it to relieve itself except upon the point of rigid termination. In our present method of construction of locomotives the boiler is the basic element of the whole structure, the foundation as it were, and therefore sustains the final reception of all reactionary forces. Now, as forces act in precisely equal quantities in opposite directions, the entire quantity exerted in the service of a locomotive, whether from concussions arising out of movement over the rails, or by the movement of the pistons in performing their work, reacts; and although so indefinitely drawn out as to be exceedingly minute when their final reception within the structure of the boiler obtains, yet they are all absorbed therein in the shape of quivering vibrations, which in turn absolutely terminate at all perfectly rigid points. Thus the longitudinal laps or seams of the boiler, and the points where the feet of the frame braces are riveted to the boiler, being the points of reception and final termination for these reactionary forces, are the points where the sheets or plates first give way; but there can be no points where abrupt changes of quantities of material occur, or where rigid attachments of one portion of the structure of the boiler are made to another portion, without making such points at the same time weak, in the sense that they thus become terminating reception points for the reactionary forces. If you attempt to break a piece of wire you have to hold it so that the movement thrown into it terminates at one single point, and immediately the effect is seen by the separation of the metal. The change in the structure of the metal, in my opinion, arises entirely from that cause. This element of movement, as you might term it, thrown into the internal structure of the mass must relieve itself finally at a terminating point. It is impossible for the force to pass a lap; it must terminate there. There is the point of separation, and there is no tendency to separation a short distance from there, but directly on that line. The same result is observed in the fire boxes from the same cause. While, as has been remarked, this cracking of the boilers is mostly in the side sheets, it must be remembered that the side sheets unfortunately, as many of us know, are often badly used by deposits of sediment accumulating in the leg of the boiler. We ought to be ashamed of it; but it is not an unfrequent thing to find boilers with a lining of mud in them, which is another cause of weakness, that in itself is an element of movement, because the strain thrown upon the boiler by the difference in temperature of the iron or steel, caused by the mud, is at a point below the mud; and although it may not be more than half an inch thick, the temperature of the sheet is very different at that point from what it is where it is in direct contact with the water. Therefore, there is a mode of motion in that difference of temperature. I commenced to make these remarks simply to call your attention to the fact that there had been boilers with steel fire boxes in use since 1860, and that they had done remarkably

well. I attribute the fact of their endurance to the care that was taken by the constructors of the boilers to carry out this idea of thoroughly annealing the plate, not simply heating it, but to bring it up to a heat sufficiently great to allow these strains time enough to diffuse themselves—twenty-four hours is not too long for such a thing, and the process required is not what we ordinarily call annealing. I do not know that the steel used in these boilers was of very excellent quality. It was Charles Campbell & Co.'s imported brand, but it was not as good material as we are manufacturing to-day in this country; of that I am satisfied. What I want to say, is simply this, I believe that if care is taken in the first place in the construction of the fire box, to thoroughly anneal the plates, or to bring them up to a sufficiently high temperature, and then give them time enough under that temperature to allow every particle of the strain that has been thrown into them by the manipulation of the sheets, to assert itself and be diffused throughout the entire sheet, you will have done all that you can to secure satisfactory results in the use of steel for fire boxes.

Mr. Boon, Pittsburgh, Fort Wayne & Chicago Railroad—I do not think that annealing the sheets would prevent the cracking. The side sheets are the ones that fail, and there is less work on them than on any of the others. They are perfectly straight sheets, and all the work that is done on them is to punch the holes for the stay-bolts and rivets. If the want of annealing will break them, why will not the fire-door sheet break? It is worked more than any other of the fire box and is flanged out very heavily, yet I have never heard of a single instance where a fire-door sheet has cracked. If mud accumulates in the water space it might do so, but where the boiler was perfectly clean and the water space three or three and one-half inches there is no instance reported where the fire-door sheet has cracked. It is the side sheets and no others that give trouble. I do not think that annealing will prevent this. The sheets at the point where the difficulty occurs are put in place as straight as they come from the mills and without being subjected to very much strain, if any.

Mr. Sedgley, Lake Shore & Michigan Southern Railroad—For the last four or five years I have had some experience in the use of steel boilers, and I differ somewhat from the gentleman of the Fort Wayne Road as to the manner of handling the side sheets. When the plate comes from the rolls it is sheared to the right dimensions; and it is fair to suppose that in cooling, after heating, the outside edges cool first; and, that being the case, there must be a strain upon the sheets. All the trouble I have had from furnaces has been from the side sheets, and I attribute it in a great measure to that one cause, that the builders do not perfectly anneal them. I would like more information on the subject if we can get it from those gentlemen who make these plates, and also from those who have built so many steel boilers within the last four or five years. As regards the outside of boilers, I think there is a question as to the quality of material that should be used. On portions of a

road where iron boilers have failed in three years and required patching, we have been running steel for the last six or seven years without any apparent depreciation. Out of some three hundred steel boilers I have had no trouble with the outsides; but, perhaps, from five to seven per cent. of the steel fire boxes have cracked, more or less, and it has been almost invariably upon the side sheets, and in those engines that were in very heavy service. They cracked diagonally, commencing forward of the arch and running back. How to remedy this has been a very serious question with me, and I would be very glad to get information about it. I would like to know if those sheets were properly annealed before they were put in, although I have come to the conclusion that it is impossible to change the nature of steel by annealing. I think it will go back to its normal condition by use, but the strains may be equalized.

Mr. Brooks, Brooks Locomotive Works—Will you allow me to interrupt you to correct an impression which seems to be gaining ground here. There is a distinction between annealing and the process ordinarily *called* annealing. I do not think it sufficient to put these sheets through this process simply for the purpose of softening them. There is an elasticity of structure thrown within the entire sheet, not only in its original manufacture, but in its subsequent manipulations, and that strain has got to take time to assert itself. It can be helped by treating the sheet to this process under the influence of an elevated temperature to distribute the strain throughout the entire structure, and if this is properly done we may be able in a few hours to accomplish what otherwise would take months and even years, and under the old process might then result in a fracture. The idea is not to soften the sheet, but to allow these strains that have been thrown into it by manipulation to assert themselves throughout the entire structure.

Mr. Sedgley, Lake Shore & Michigan Southern Railroad—I would be very glad to hear the views of other gentlemen in regard to this subject, because it is a matter of vital importance to us whether we can continue the use of steel as it is now manufactured.

Mr. Hudson, Rogers Locomotive Works—The subject of annealing steel sheets has a most important bearing on this whole matter. Take, for instance, the side sheets that are not flanged; the punching of the holes and the hammering that takes place on the outside of the sheets tend to lengthen the outside and to put a strain upon the center of the sheet. Annealing restores the sheet so that the tension will become more uniform throughout the structure. When sheets are flanged, if the strain due to the flanging is left in them, that strain is of a tensile character on the outside of the sheet, but of a compressive character on the center of the sheet. Hence, if a sheet were to crack from that cause, it ought to crack on the outside and not in the center. Sheets crack because the tension is in the center. We have strained the outside of the sheet by punching the holes, and have not taken pains to relieve it afterward, and the result is a crack, because of the effort of the

sheet to equalize these strains. If sheets are properly annealed after being punched, somewhat of this strain is removed. But I apprehend, as Mr. Brooks says, that sheets are liable to have these strains produced in them by the treatment they get in the locomotive. For instance, when mud accumulates in the bottom of the fire box we all know that the effect is to prevent a uniform temperature throughout the sheet, and whenever a portion of a sheet contains a higher temperature than another portion a strain must be the result. For instance, if we heat the center of a sheet more than the outside, the sheet can not yield sidewise because it is tied at the outside by stay bolts. The result is that the fibers of the sheet are pressed together so that the sheet becomes actually shorter in the center when the high temperature is removed. The consequence is, when the sheet cools down there is a tensile strain in the center of the sheet, and if this is repeated often the sheet is caused to crack. It is not a wonder to me that sheets crack, knowing as I do what kind of treatment they sometimes get. I am sorry to make this remark, because it is not very complimentary; but I have been on railroad lines and had charge of locomotives, and I know that we can not always prevent their abuse. I have seen mud more than a foot deep in a boiler. It ought not to be there, but is frequently allowed to accumulate from various causes. I have known this to occur on railroads that were short of power. They bring an engine into the shop, blow it off, and without waiting for the boiler to cool water is put in as rapidly as possible, and they are again sent out. If steam gets up without cracking the sheet it is all very well, but if it does not then the cry is "bad steel." I think this is bad treatment rather than bad steel. I do not know of any material that will stand that kind of abuse indefinitely. I have no doubt that on some roads locomotives get a great deal more such treatment than on others. I know that sheets crack from bad usage sometimes rather than from bad steel, because I have tested pieces of sheets that have cracked in every possible way, and have found that the material was good; and so far as any body could judge, was as good as it ever was, and just as good material as you could put into a locomotive, and yet it cracked. How shall we account for this cracking? I go upon facts, because an accurate knowledge of what really takes place is what we all want to get. We must know the precise nature of the disease before we can apply the remedy.

Mr. PERRIN, Taunton Locomotive Works—I very well remember the circumstance referred to by Mr. Brooks, and I know that we took extra pains to anneal those flanged sheets—a course we have adopted from that time to this. We have regarded it as an important point to take the strains from the sheets, since we believe that every sheet that is rolled is strained in different parts as it goes through the rolls; and it is necessary, as far as possible, to take out that strain by placing it in a furnace and heating it evenly, and letting it remain there until it cools off. This will reduce the strain. I think that, perhaps, the thickness of the steel has something to do

with its tendency to crack. We are apt to use both iron and steel of too great thickness in boilers. A thinner steel gives a more even expansion from one side to the other, especially if it is covered with mud on one side, with no chance to get the water to it. The thicker the steel the more difference there is in the expansion of the two sides. I remember in former times that we commenced the use of one-fourth inch iron for the outside sheets of boilers. We never heard any complaint of them, and I do not know how they stood. Then for a long time we used five-sixteenths inch for fire boxes. With steel we have almost invariably used one-fourth inch for side and back sheets, seven-sixteenths for flue sheet, and five-sixteenths for the crown sheets. We have had very good success in the use of steel, and I attribute it to annealing the plates after being flanged. I do not recall an instance of having sheets crack after being thus treated.

Mr. BROOKS, Brooks Locomotive Works—I would like to call upon Mr. Sedgley for further information on this question. He has seventeen locomotives constructed by us, the fire boxes of which are of one-fourth inch plate, with the exception of the flue sheet, which is one-half inch; the grates are sixty-two by thirty-five inches, and the cylinders sixteen by twenty-four inches. He uses a brick arch, which is certainly an extra strain upon the side sheets. I would like to have him state to the Convention the effect of the use of that, as compared with thicker steel that he has in service.

Mr. SEDGLEY, Lake Shore & Michigan Southern Railroad—I will cheerfully answer Mr. Brooks' inquiry, as far as I am able. None of the fire boxes of the engines that he built for our road in 1871 have cracked. They were, however, all freight engines, and we have had very little trouble with freight engines; but I think that, instead of those being sixty two inch grates, they were sixty-six inches.

Mr. BROOKS, Brooks Locomotive Works—The first three were sixty-two inches, and the others sixty-six inches.

Mr. SEDGLEY, Lake Shore & Michigan Southern Railroad—We have had no trouble with them at all. They have given us uniformly good results. We have also had a large number of engines having steel fire boxes built by other companies, and we have had no trouble with them on freight trains. Our trouble has been with heavy passenger engines, engines that we have forced to their utmost capacity. Those who travel upon our road know that some of the trains are very heavy. On a number of our engines we carry one hundred and forty pounds pressure in order to do the work. We carry one hundred and forty pounds pressure on boilers that are three or four years old. These are made entirely of steel, and they show no signs of depreciation. I am, therefore, led to believe that steel is much preferable to iron for even the outside of boilers. The outside sheets of the boilers I refer to are made of five-sixteenhs inch steel.

Mr. FRY, Philadelphia & Erie Railroad—The latest number of the Railroad Gazette has just been handed to me, and if not out of order, I would like to read

a paragraph from a discussion on this subject of annealing steel sheets: "During the discussion it was also stated by Mr. Bessemer that, in punching a hole in a rigid material like steel, the grain of the metal in the neighborhood of that hole is very much disturbed and greatly distressed; and I am told that plates lose in strength in punching about one-third, and that, on annealing, the whole of that one-third is restored." I thought it might be interesting to the members to know the opinion of scientific men upon this subject. I imagine that we are essentially a practical institution. I think it is of great importance to ourselves, and will be looked upon as of great importance by scientific men, not only throughout this country, but also in Europe, if we can give the practical results attained by members of this Association in the use of steel. Two of our members have already stated their experience. I wish that Mr. Sedgley would state his more accurately. He thinks that four or five per cent. of his fire boxes fail before they ought to in consequence of the cracking of the material. I wish he would state exactly the proportion. Another Master Mechanic has stated that, of eighteen boilers made of steel, none have failed. If we could have the experience of all the members who have tried it, it would be of great importance. I would like, not merely the scientific reasons for using steel, but the practical effect of its use. No institution in the world, in my opinion, is so able to settle this question satisfactorily.

Mr. Hudson, Rogers Locomotive Works—It is very evident that the size of the sheet has a good deal to do with its liability to crack, and this liability seems confined almost entirely to the side sheets. We have very little complaint of the crown sheets or the part below the tubes cracking. Those are flanged, and are subject to all the strains that the other sheets are, excepting those that result from the difference in size. The larger the sheet is, the edges being held rigidly and the center made hot, the greater is its tendency to crack, because a greater compressive strain is brought into the material when it is heated, and a tensile strain when it cools off. I think that corrugating the sheets in some manner between the stay bolts, and allowing them to accommodate themselves to the various strains, either tensile or compressive, would tend in a great measure to prevent the cracking.

Mr. Setchel, Little Miami Railroad—To me this is more important and more interesting than all the subjects that we have before the Convention for consideration. The boiler is the foundation of the locomotive, and it is essential that it should be made of the very best material. I have looked over this matter of boilers and boiler materials, and have heard the discussions on it from the first to the last. In 1868, in a Convention held at Pittsburgh, we had the first report on boilers, which was made by Mr. Hayes, of the Illinois Central Road; Mr. Anderson, who was then of the Chicago & North-western; and Mr. Jauriette, of the Chicago, Burlington & Quincy Road—members who were, perhaps, managing longer lines of road than any other three members of the Convention at that time. The Committee com-

menced the report by saying that they had, by proxy or otherwise, visited most of the leading roads in the United States, and had obtained very largely the result of the experience of the Master Mechanics in regard to the best material for fire boxes and boilers. They must have gathered from that the fact that there was a necessity for a change from what was previously used, or what was being used at that time, as they strongly and unhesitatingly recommended the use of steel for fire boxes, especially for coal-burning locomotives. There was no discussion upon that report. I believe there was not a single remark made, except the motion to receive it. On the second report there was some discussion. Mr. Anderson, of the Chicago & Northwestern, remarked, in substance, that we must have some better material for fire boxes; that copper was a failure; and that he had about thirty engines, the fire boxes of which must be renewed that year, whose average life had been less than three years. So you see that, at this time, there was a great necessity for a change in the material used; and the Committee recommended, as before, the use of steel, but incidentally remarked that the only objection there could be to its use was that it *sometimes cracked*—a propensity that has been steadily developing since that time. At the time of the third report the Committee had, by circulars, been making inquiries throughout the country, and the fact was developed that a great many steel sheets had cracked. The following year there was a report on that subject, and we find that a large number of Master Mechanics gave it as their experience that steel sheets, as then manufactured, were too hard, and would crack. Mr. Hayes, in the course of his remarks in the discussion on this subject, stated that he was not using, and could not use, steel for crown sheets; and it was remarked by Mr. Eddy, from the Boston & Albany Road, that he did not use steel sheets at all, and that his friend Mr. Hayes (you will all remember the remark) was beating about the bush, and that he was gradually going back to the use of iron for fire boxes; that he had got the crown sheets of iron; by and by he would have the flue sheets, and after awhile he would have all iron. Mr. Hayes answered that it was impossible for him to use steel for crown sheets on the road that he represented. So we see that there is a difference of opinion as to the practicability of using steel, at least in certain localities, while it may be used with advantage in others—and so this matter has gone on from year to year. We find that the report of the Committee this year, shows very conclusively that a very large number of steel sheets are failing all over the country. Now the question is, is steel the proper material for fire boxes? It seems to me that the only practical way to get a solution of this question, is to secure the experience of every member as to its durability. I believe, if we could get the experience of every member in this Convention representing a railroad, that we would obtain more real information, and be able to form a better judgment than we can by relying on our own experience. I will give my experience on both sides of the question, and in turn would like to hear from every other mem-

ber present. We have two engines with iron fire boxes on our road that have been in constant service since 1860; they are now in good condition with no fracture about them. During seven years of that time these engines have been burning coal. We have another engine with an iron fire box that has been running seven years. It has run forty-two months with coal, and in that time has run one hundred and forty-nine thousand eight hundred and fourteen miles, or an average of one hundred and fourteen miles for every day of that time, Sundays included, and that on very hard service with hard water. These are arguments in favor of iron, but I am not going to say on that account, that we must use iron entirely. Then, on the other hand, we have engines with steel fire boxes, burning coal, that have been in use seven or eight years, and are still in good condition. I should say, however, that they have been burning coal only five or six years of that time, and that they burned wood during the first two years; which fact, in my experience, has made a very marked difference in the durability of fire boxes. In all cases where we have burned wood during the first year or two in engines before commencing to use coal we have had no trouble with the plates cracking; and the same fact holds good with iron fire boxes. I have here a piece of steel taken out of a fire box after it had run twenty-five thousand eight hundred and sixty-four miles, which cracked while standing in the engine house after it had been there thirty-six hours. I can assure you that there was not a particle of mud in the water space. We wash out our engines every week, through rear and back of the fire box, taking out the washout plugs placed there for that purpose; and through the front end of boiler every two weeks. We do this without exception. This engine that I refer to had been standing in the round house thirty-six hours and had become comparatively cool, and the side sheet cracked just after the fire had been put in, but before any steam was raised. Here is a sample of the plate after being heated to a red heat, then plunged in water, and then doubled down. I have here another piece of the same sheet just as it came from the box; that broke with a light tap of a hand hammer over an anvil. Some gentlemen will say that the steel was too hard, and that was the cause of the fracture. It is quite easy to say this, but to prove it is another thing, as I will show you by exhibiting a specimen that is soft and ductile, taken from another box, that cracked while the engine was standing in the house, after it had made a total mileage of seventy-four thousand four hundred and seventy-four. This piece was cut from the sheet in the same condition as when taken from the box, and bent down cold. If you can find a piece of better steel than this apparently is, I would be glad to see it. The crack in this last case began just above the fire and ran up, and, as has been remarked by the Committee, did not follow a straight line, but ran across from one stay bolt to another, and a little back of the center of the box. So we see that the soft steel cracks as well as the hard. I do not offer any theory, but simply state the facts in my experience, and if I were to rely entirely on that I would hardly know which to choose—iron or steel. Our

iron fire boxes have run the greatest number of miles with coal, but I am led to believe that these are exceptions, and that generally steel is the best material for fire boxes. But I want to hear the experience of other members of the Association, to see if I am justified in coming to this conclusion. Something has been said about the undue strain that is put upon sheets by not properly annealing them. I do not think it can be shown that there is any undue strain in the side sheets that should cause them to crack; for, as Mr. Hudson has said, the outer edges of the plate cool first, and the strain on the sheet would be in and not out; whereas, the sheets when they give way seem to be too short instead of too long; and there is very little strain put upon the sheet in the process of manufacturing the fire box; the stay bolt holes are drilled and the sheets that give all the trouble, many times, are neither punched, flanged nor rolled, and it would seem strange, to say the least, that these sheets crack from undue strain, when the door, flue, and crown sheets, which are flanged and heavily worked, do not.

Mr. Hudson, Rogers' Locomotive Works—I would like to correct an erroneous impression that Mr. Setchel has obtained from what I said. I did not mean to say that the side sheets were under compression rather than tension. I meant to say that the work of punching and riveting the side sheets has a tendency to pull them apart in the center; whereas, in the sheets that are flanged the strain is of an opposite character. Mr. Setchel stated that the side sheets were carefully annealed. I would like to ask if that annealing was done after the punching of the side sheets, and whether the stay bolts were punched or drilled?

Mr. Setchel, Little Miami Railroad—I did understand Mr. Hudson to say so, but whether he said it or not, that is the fact in the case as I understand it. If there is any difference in the length caused by the cooling of the sheets in manufacturing, they are longer inside. The sheets in use are heated in the center, and they become longer, and have a tendency to full up in cooling. When they crack we find that they are short in the center, and, as the Committee stated, the cracks invariably open, which shows that the sheets are too short in the center. Those fire boxes that I have referred to were of our own manufacture. We drill all the stay bolt holes, and the sheets are carefully annealed over a slow wood fire before placing them in the box.

Mr. Sellers, Philadelphia—There has been a great deal said about the use of steel, but I have heard very little about the *quality* of the steel used. Steel differs very much in quality when made by different processes. I might say for the benefit of the members present who may not be aware of the fact, that there are three types of steel. The earliest form is that made in crucibles; another form is the Bessemer; and the other is the Seiman-Martin steel. The process used in making the last variety seems to be the one that is likely to produce the most uniform and satisfactory results for boiler purposes, because in that *definite quantities* of materials are used which

have been carefully analyzed and found to contain certain ingredients which are known to be the ingredients of the best quality of steel; as, for instance, definite quantities of carbon, magnesia, and phosphorous. A mixture can be made and kept at a certain temperature, for a certain length of time, in a large bulk, and, when reduced to plates, be known to have the required quantity of carbon in it. One of the specimens of steel shown to us by Mr. Setchel seems to contain a very small amount of carbon, but we can not tell anything about that without analysis. If the plates that have cracked should be submitted to an analysis to determine what the quality of steel was, then we could see whether it was the quality of the material that induced the plate to crack, or whether it was the form of the boiler. It seems to me that the sides of the boiler is a part of the frame that supports the engine, and that from their position and structure they are made to receive a strain that the end sheets of the boiler are not subjected to, and that for this reason they are liable to crack. The side sheets of the boiler are submitted all the time to this strain, which ultimately produces a change in the nature of the metal. I think, therefore, that the form of the boiler has much to do with the tendency to break. I just asked a gentleman whether iron sheets put in the same place and submitted to the same strain break, and he states that they do. It may be, therefore, that it is the form of the boiler rather than the material of which the sheets are composed, which increases the tendency to crack. Not many years ago, when the world was greatly excited about the introduction of steel, certain ships were built on the Clyde and sent out. The supposition was that steel being so much stronger than iron, could be used much thinner in the construction of ships. What was the result? They put steel in these ships, using much thinner plates than they had been formerly making of iron, and the result was that these ships were nothing in the world but man traps. They all went down or broke to pieces. In a locomotive the thinness of the sheet may have to be considered with reference to the rivet holes and the strain that the sheets are submitted to. Some portions of the boiler may require to be thinner than others, when submitted to greater side strains; and, as I have suggested, the boiler must be so constructed as to support the increase of weight given to it because of the peculiar construction of the engine. And if you take away the boiler from the locomotive, the frame is nothing at all. The frame is added to the boiler to make a certain structure, which is called a locomotive. This structure has a certain rigidity and a certain flexibility; and, therefore, the strain in boilers always differs with the form of the structure of the boiler. My friend, Mr. Brooks, has said a good deal about annealing, but I think there has been a misunderstanding of the opinion he desired to express. I do not think that he meant to say that the object to be accomplished was to submit the steel to the annealing process; if he had said that it should be submitted to a slow cooling process, he would have come nearer to the fact. It was ascertained years ago that glass could

be made tough by a slow cooling process. That was called annealing the glass, but it was not the correct term. Annealing does not soften the glass, for the glass is as hard after the annealing process as it was before; but it has the strain taken out of it by allowing it cool down as slowly as possible from a high temperature. We consider glass very brittle, yet there are traditions of a flexible glass—of a glass that could be bent; and it seems almost as if that lost art were being found in this process of slow cooling. In Europe glass is now made pliable by being heated to a red heat, then plunged in oil and slowly cooled. The result is such a difference in the glass that, while that which has not been submitted to this process will break from the mere dropping of a small bullet upon it, a piece of glass which has been so treated is made so tough that it will not break, even though a heavy bullet be let fall upon it from a distance of sixteen feet or more. This is true of glass, and it may be true of steel that a difference in the method of cooling it will enable it to better withstand whatever strain it may be put to.

Mr. HUDSON, Rogers Locomotive Works—A week or so ago we had a letter from a Master Mechanic of the Pennsylvania Railway, inquiring of what metal the fire box of a certain locomotive, built at our works twenty years ago, was made. On looking the matter up we found that it was made of Low Moor Iron. They informed us that the same box was still in use and in very good condition. I also had a letter a short time ago from Mr. Graham, Master Mechanic of a railroad in Cuba, who stated that he had two locomotives having iron fire boxes that had been in constant use for eighteen years and were yet in serviceable condition, although one of them had several patches on it. As to the quality of the steel best to be used, I would like to inquire how we shall know when we have got the right quality. I think that is a very important question. I would state that we are constructing some locomotive boilers entirely of steel, the plates of which have been thoroughly tested and stamped. The tests are confined to tensile strain of sixty-five thousand to seventy thousand pounds. We are not to take any sheets which do not bear that strain. I find the material works remarkably well, and, as far as I can judge, I think it will make a very durable boiler, but that remains to be seen.

Mr. BROOKS, Brooks Locomotive Works—I would like to make a motion that each Master Mechanic here present be requested during the next year, if from any cause they shall have steel sheets crack in fire boxes, to preserve a portion of the sheet as a sample of the steel, and carefully mark upon it all the data that may be of use, such as the service of the engine, the fuel used, the time in use, etc., and that they bring such samples to our next Convention, and that the samples be then submitted to a special committee appointed to test them. The whole subject may then be carefully investigated in connection with those samples. We could have them analyzed, as Mr. Sellers has suggested. In this way, doubtless, some definite and valuable information can be gathered in regard to the use of steel.

THE PRESIDENT—Do you make that as a motion?

Mr. BROOKS, Brooks Locomotive Works—I do make that as a motion.

Mr. FRY, Philadelphia & Erie Railroad—Before seconding Mr. Brooks' motion, I would like to ask him to add, that the Master Mechanics give the average life of their fire boxes, for I think it is important that we should know this.

Mr. BROOKS, Brooks Locomotive Works—My object was simply to bring this subject before the Convention and manufacturers of steel, There are other parties who are interested in this matter, and would be benefited by our experience just as much as the locomotive builders and Master Mechanics.

THE PRESIDENT—It has been moved and seconded that each Master Mechanic of this Association take due notice of all fractures and cracks in fire boxes occurring within the next year, cut out pieces from the plates which crack, and carefully mark thereon all that may be interesting, as the life of the fire box, the kind of fuel used, etc., and bring the specimens to the next meeting of the Convention. Are you ready for the question?

Mr. SETCHEL, Little Miami Railroad—I am very glad that that motion has been made. I brought these specimens, and I was in hopes that there would be more samples here of the same kind. I would suggest that in cutting out the piece a portion be cut parallel and next to the crack.

Mr. OSBORNE, Grant Locomotive Works—Do you think that that would show where the disease is?

Mr. SETCHEL, Little Miami Railroad—That is the idea exactly. In the manufacture of fire boxes we have adopted this practice: We cut off a piece of steel about two inches wide, just as it comes from the manufacturers, and double down one end of it cold; then we heat the other end and plunge it in water and double that down. If the steel hardens so as to break we do not use it; but we have not had any so hard as that yet. We put a label on the piece, with the number of the engine in which it is used and lay it away, so that we have a specimen of the steel as it came from the manufacturer, bent both hot and cold. Then, if that sheet cracks, we cut a piece from the cracked sheet, and thus have a specimen of the steel, both before and after it has been in service. If this course were universally adopted and the specimens analyzed, we would then be able to decide what particular composition of steel is most liable to crack, and manufacturers would be able to determine just what quality of steel is best adapted for fire boxes.

Mr. COLEMAN SELLERS, of Philadelphia—I want to say a word more in regard to the quality of steel. I am anxious to have some action taken by this Convention in regard to it, if possible. Some time ago there was some steel failed, which I had occasion to take an interest in, and which had been made by a manufacturer whose steel heretofore had always been reliable. I saw the maker and asked him if he could tell me how much carbon there was in that steel. He said he could not, but that it was exactly the same mixture that he had used for a number of years, and he expressed great sur-

prise that the steel had failed, because the mixture was a good one. I pressed him for an opinion as to the amount of carbon used, and he could not tell exactly, but thought it was one-half of one per cent. Here was a large establishment, manufacturing a great quantity of steel, yet not knowing the proportions of the mixture used. Another maker analyzes all the material that he puts into the steel, and can tell you exactly what it is—whether it contains one-fourth of one per cent. of carbon or more. I would like to have the steel makers themselves investigate this matter. Such an investigation as is proposed will do them as much good as it will us. We need some definite knowledge of what the thing is that we are putting into our boilers and calling steel.

Mr. CASCADDIN, Chicago, Rock Island & Pacific Railroad—Had I not supposed my General Master Mechanic would be here to give the important data that he has collected, I should have come better prepared to make some remarks on this subject myself. He has kept watch of this matter, and the Division Master Mechanics have made reports to him, which he has compiled, and I fully expected that he would be here to give the experience of our road, and did not learn that he would be absent until I came through Chicago on my way here.

The resolution of Mr. Brooks was then adopted.

Mr. ROBINSON, Great Western Railroad—I would like to answer one or two questions that have been put before the Convention, and I will reply first to the inquiry of Mr. Brooks. He referred to some engines that were built for the Great Western Railway in 1860. There were five engines built for the road in that year. The boilers of these engines were not made of steel as we call it now, but it was what was called at that time semi-steel, or a homogeneous metal, and that is one reason why these boilers did so well. It was one of the first trials of this metal, and therefore it was prepared very carefully. We wrote to England for it, and told the manufacturers that it was an experiment and a great deal depended upon the results. Those boilers were in successful use for thirteen years, and they were then removed simply in consequence of a change of gauge in the railway. Two of the boilers were sold to some other line and were used for a short time, and two are now in use in the car works as stationary boilers, where I presume they will be used for ten or twelve years longer. The metal used in those boilers has certainly given good satisfaction.

Mr. BROOKS, Brooks Locomotive Works—Will you state whose homogeneous metal that was?

Mr. ROBINSON, Great Western Railroad—I think it was Campbell's, of Sheffield. I would like to say a few words on the subject of fractures in fire boxes. There is an argument which does not hold good at all times, but still may be pertinent in this connection. It is rather an absurd one and may be used in two ways. It is said that "the early bird catches the worm," and of course the counter argument is that if the worm had not been there

so early he would not have been caught. Now, there are a great many things that hinge upon an argument of that kind, and I refer to it to show more particularly what I mean in the remarks that I may make. We take a number of fire boxes, and on examination we find that a crack or fracture takes place in one of them. Now, if the same cause of fracture existed in all the fire boxes, we would have reason to suppose, by argument, that all of the fire boxes would crack in a similar way and in the same place. We do not, however, find that to be the fact. Only a small percentage of these fire boxes crack at all. If it is only a percentage that cracks, then there must be some cause existing in that percentage that does not exist in the others that do not crack. It is, therefore, our duty to find out what is the cause of the cracking, and to ascertain what facts exist in the minority of instances that do not exist in the majority. Having found these causes, then our business as good Master Mechanics is to remove them. For that reason I am pleased to see that we are placing more importance than heretofore upon this subject. In regard to strains on the metal, I think the argument has been made, and it is a very pertinent one, that there are a great many strains on iron and steel which we have not considered this morning. Mr. Brooks has mentioned that we can not give any piece of metal a blow without causing some injury to it. If we have a bar of iron that is straight, and we want to make it slightly curved, or one that is curved and we want to make it straight, we know that, if we strike it with few blows on one side only, the metal will expand on that side and become longer on its surface than on the other. The consequence is that there is a greater extent of expansion of the particles on one side than there is on the other, and so the iron becomes curved in that part. We will suppose that it takes a thousand blows to give a bar of iron a certain curve, or to produce in it a strain that will cause it to break, then each blow is one-thousandth part of that strain. On this principle I contend that every unnecessary blow imparted to a boiler plate by the boiler maker is an unnecessary injury. For that reason I think we have one cause of the partial failure in the attempt to use steel in boiler making. When the time comes for us to make steel boilers without any extra blows whatever upon the metal, then I think we will cease to have many of the difficulties that we are now encountering. There is one strain that has not yet been mentioned to which flat plates are subjected. Members have expressed surprise that flat plates crack when the curved plates do not, but there is no reason for surprise at this. In a plate that has a curve in it there is a direction for every strain that is imparted to it to exert itself. It will go in the direction of the curve and will thereby relieve itself. We know that in using the delivery pipe of pumps, or any pipe in which a strain exists, if they are curved in one direction, the throb or vibration which takes place will be less injurious to the pipe than it would if the pipe were straight. In straight pipes the joint will often give way or the pipe burst, because there is no opportunity for the strain to distribute

itself and die away. For that reason I am not surprised at all that flat plates fracture. It has been said that the manufacturers are very careful in annealing their plates after the punching and drilling, yet I fancy that by annealing they do not succeed in distributing over the whole plate the unnecessary blows of the hammer that are often given it. The time will come when we shall avoid all these extra blows on the metal when we make boilers of steel. I think that the stay-bolt holes are another great cause of fracture. Although there may be some fractures that do not take place there, yet in the majority of cases I think they are the starting points of the fracture. It may be said that they start from the bottom, but we know very well that the boiler makers in caulking the boilers will give the plate a great many blows at the bottom on the caulking edge. We do not watch every blow that is given there, and some very unfair blows may be dealt, starting a fracture, perhaps, where a strain already exists. Until we know what injury has been done to a plate, we are not in a position to say what is the cause of any after failure. For that reason it behooves us as Master Mechanics to give more attention to the manufacture of boilers than we have done heretofore. It has usually been the practice of locomotive constructors to bestow a large amount of attention upon the valve gear and upon the general appurtenances of the engine, but not so much attention has been bestowed upon the boiler as is required. Master Mechanics must pay more attention to the boiler sheets; they must take a piece of each plate that is used and place it in their museum, properly marked, so that when a fracture takes place they can tell what started it, and by this constant watching we shall be able to gain some more definite information than we now have. Another point has been mentioned, and was first referred to by our worthy President in his opening address. He said it had been remarked that we have not yet arrived at any fixed conclusions. Whoever made such a remark was not a scientific man, or not sufficiently scientific to know that the more a man knows the better he is able to appreciate how much more he has yet to learn. We shall find, each year as we come together, that there is more and more information to be ascertained by our experiments and observations. It is a most curious fact that, though the most scientific men may study and study over any given subject, yet they must learn from actual experience a great many of the important details of their professions. Some of the things that we had thought established beyond a doubt are upset by some new developments of art or science. Who would have presumed to say that the engineers who constructed the first railway were unwise in placing the rails upon stone ties? It was thought to be one of the most magnificent inventions ever made. They thought that they had a foundation for a railway that would last a hundred years. No one can deny that the projectors of that enterprise were scientific men for those times, but it was not many months before they found out that they had made a grand mistake, for the whole structure had to be taken up and

replaced by the wooden ties that we use to-day. They found that they had made an egregious error; we must be careful that we do not make a similar error. We are to profit by the experience of the past as well as by our own researches. We must in this matter be honest with ourselves, with our companies with which we are connected, and with the public. There is so much to be learned that we must be careful in announcing the results of our investigations. For instance, the report on boilers, referring to the use of brass, iron, and copper tubes, says that where the water is bad iron tubes are found to be the best. On our Western Railway we have about fifty locomotives which are furnished with iron tubes. We soon found that they would not answer the purpose, and they are now being replaced with tubes of brass or composition metal. The reason for the change is this: the water is bad, peculiarly so (it is principally from Lake Ontario), and has a strong affinity for iron; and before the engines have run a year the iron tubes will become incrusted with a scale so hard that we can scarcely remove it. We find that brass tubes do not collect this sediment so rapidly, and it can be more easily removed from them, after running two or three years, than from iron tubes after running a single year. You will probably not find this to be the case on other roads. That is one fact showing that we can not apply the same medicine to the same disease in all localities. I think, with Mr. Sellers, that a great deal depends upon the quality of the metal used; but, even if we should succeed in getting just the same quality in all our boilers, we would still have different results, because in some cases there would not be perfect workmanship. Mr. Setchel has shown us a piece of metal from a boiler which was broken with the tap of a hammer. There was a very good reason, we say, for that boiler to give way—the steel was too hard. I think that we must have a metal which shall be of a low, soft grade, so that, after eight or ten years' wear its nature will still be such that it may be bent while cold without breaking. I quite agree with the remarks made about annealing; I do not think annealing is the proper word. It is a well-known fact that if you put turpentine on a boil when it commences to come out upon the body, the turpentine will scatter it, and you will probably feel nothing more of it. It does not take the boil away, but it scatters it, and I think that the same thing is done in annealing. You have a strain in a boiler plate, but by the process of annealing that strain is diffused through the entire plate instead of being confined to one part of it; in other words, the strains are equalized, but I do not think the nature of the metal is changed. My experience in the use of steel boilers has been asked for. We have over two hundred boilers with iron shells and steel fire boxes, and I think only one has cracked out of the number that has been running three or four years; thirty of them are using coal, the others wood. For my own part I honestly and candidly recommend the use of steel; but it should be *good*, and the boiler should be constructed in the *best possible* manner. If that is done I would prefer the steel to any other metal I have ever used for

that purpose. In the outside sheets I think it is immaterial whether steel or iron is used. After awhile we shall have some definite means for testing steel and iron, so that we may be sure we are purchasing a reliable metal. I will not detain you with further remarks upon this subject, except to express my thanks for your attention and the information given by other members. If we carry out the resolution that has just been adopted, and endeavor to bring in the results of our observations at the next Convention, we will have a much more reliable basis for judgment then than we have now. I am sorry to say that we do not pull together in the way that we ought in respect to answering the circulars sent out by the various committees. The committees have a very laborious work to perform, and each Master Mechanic should be prompt to aid them to the full extent of his ability. Perhaps there might be some improvement in the form of the questions; they might be put more pointedly, so as to elicit the specific information desired. If we all do our duty in this respect we will gain much valuable information during the coming year.

Mr. FORNEY, Railroad Gazette—I think that every member here will agree that in building boilers we should only use steel of good quality; and we would all be extremely grateful to Mr. Robinson if he could tell us how to determine whether steel is of good quality. That is exactly what we are after, and probably what we want more than any thing else. I hope, therefore, that he will enlighten us as to the means by which we can determine the quality of steel.

Mr. ROBINSON, Great Western Railroad—I shall probably be able to give you an answer at some future time. There are certain tests by tension and by bending which are sufficiently accurate to give us a tolerably correct idea of the quality of steel; and there are some steels now in the market which are giving very satisfactory results, the composition of which we shall know more about by and by. I very much doubt if the steel which Mr. Setchel showed us was properly tested before it was used. As mechanics we can try the bending process and the tensile process of testing the quality, and when we become better educated in metallurgy we will then know more about it. But at present we must rely, to a great extent, upon the credit and representations of those to whom we entrust the manufacture of steel.

Mr. SETCHEL, Little Miami Railroad—This steel was tested, and the sample of the original corresponded as nearly to the sample I have produced, after annealing, as you can imagine. You could see no difference. This piece is just as it was taken out of the fire box; you can see the scale on it now. It broke easily when tapped with the hammer over an anvil. The other piece was heated to a red heat and placed in coal ashes, and when cool bent down as you see it. To all appearance it is as good steel as you would wish to have in a fire box.

Mr. ROBINSON, Great Western Railroad—Can you vouch that the very plate, from which that piece was broken, was ever tested?

Mr. Setchel, Little Miami Railroad—Yes sir. It is a piece of the same plate tested as I have before described. A record and sample is kept of each sheet, and the sample is tested and marked as being a piece of the side sheet, for instance, of Engine No. 225, and is laid away in the museum—a plan which the gentleman has spoken of and recommended to the Convention.

Mr. Robinson, Great Western Railroad—That shows that the plate, which was perfectly fibrous or sufficiently so to be able to bend cold when first put in the boiler, became like cast iron after a certain number of years of use.

Mr. Setchel, Little Miami Railroad—This had been in use only about eleven months, and had only run about twenty-five thousand miles.

Mr. Fry, Philadelphia & Erie Railroad—It seems to be a curious fact in connection with this specimen that the steel, before it was put in the boiler and after it was heated and cooled off in water, could be bent cold, thus showing that it had none of the qualities which we expect to find in cast steel; but after running a few thousand miles it seemed to turn back to cast steel. It was then perfectly hard, but could be softened by annealing in the usual way. That seems to me a very curious fact.

Mr. Forney, Railroad Gazette—We have learned one fact—that the test which Mr. Setchel applied was of no use. He obtained no reliable information from his method of testing. Mr. Hudson has stated that in his opinion the best test was to take steel of a very low tensile strength; but we find it impossible to get steel of that character with high carbon in it. I think that if the members could give us any information which would enable us when buying boiler plates to determine whether they were of such quality as would endure, it would be information of great value to the railroad world. If we do not know how to test steel let us say so, and let somebody tell us.

Mr. Setchel, Little Miami Railroad—I was not aware that there was any thing very curious in iron or steel becoming carbonized or brittle by use and being restored by annealing. It certainly is not new, and is a thing that may be witnessed every day in working up old iron or steel. I will now give the rest of the history of that fire box. The steel was of the Sheffield brand. We ordered from our purchasing agent steel for two fire boxes, and this was sent us, which was tested and then made into the fire box. In chipping the seams prior to corking, as the chisel would get under the chip, the steel would work out, or go down below the surface, just as a wart will when pulled out of the hand. And yet those sheets flanged beautifully, and seemed to be as soft as any steel could be. At the same time that this chipped out, you could discern a line running through the edge of the sheet, after it had been chipped off. Fearing that there was something wrong about the steel, I wrote to our purchasing agent, describing precisely how the steel worked—telling him about its chipping out below the surface, also how soft it was and how well it flanged. There was not a crack in it, nor the sign of one, except this dark line. I inquired of him who was using that brand of steel. He

forwarded the letter to the manufacturer, and they claim that the matter was overlooked, and that they thought nothing more about it. I watched that fire box with a great deal of anxiety, and as soon as I got word that one of the side sheets had cracked, I went to the place where the engine had laid over to inquire into all the circumstances. I found, as I have before stated, that the engine had been standing in the house for twenty-four hours, and that it cracked pretty soon after fire had been introduced to raise steam. I wrote to our Superintendent in regard to the matter, and quoted the letter I had written to the purchasing agent. I also wrote to the purchasing agent, and sent him samples of the steel, the same as I have brought here, and he at once gave it as his opinion that the steel was too hard in the first place. I brought the specimens here because the fact seemed peculiar, and worthy of careful examination. Mr. Forney says the fact shows that the test is good for nothing. If he can find us a better way for testing steel I would be glad to have him do it. You must not tear down a man's house unless you can build him a better one, and unless Mr. Forney can furnish a better way of testing steel than that which I used in this instance, it is better for him not to say much about it. This is only a part of the test. It is proposed to have the specimen analyzed, as has been suggested by several members.

Mr. Forney, Railroad Gazette—I am ready to say frankly that I do not know of any better way of testing steel. But when you come before an Association of this kind and ask for tests, it is not an answer to say, as the old lady did about the indigo, that if you put it in water it will either sink or swim, and then it was either good or bad, she did not know which. It will not do to say that you must plunge steel into cold water while it is red hot and then bend it, and if it will bend without breaking it is either good or bad, but you can not tell which. I merely say frankly that I do not know any better way of testing steel than that which was adopted by our Secretary. And that is one of the great objections to the use of steel for boiler purposes, the uncertainty that seems to attend its use at the present time and with our present knowledge. Whenever there is found a more accurate means of testing it, I shall then favor its more general use.

Mr. Peddle, Terre Haute & Indianapolis Railroad—The road with which I am connected has been unfortunate in the use of steel fire boxes. When the first fire box gave out we tried to learn the cause. We thought it was from the want of proper annealing, and after that time the sheets were carefully annealed. They were heated by a charcoal fire, and then allowed to cool very slowly; but still they cracked. I believe it is all-important to have a *good* quality of steel. We have to take the steel sent us by the makers, and have no way of thoroughly testing it—no known test but use. Last year we had two engines built by the Baldwin Locomotive Works, with Bay State steel fire boxes, the side sheets of which cracked within six months after they were put upon the road. The crack commenced a few inches above the grate, ran up from fifteen to thirty inches vertically, some-

times taking the stay bolts in the line, and sometimes going outside of the stay bolts. This shows that the sheet is on a tension. The middle of the crack is generally open one-sixteenth of an inch or more. My theory is that the sheet must be under some sort of tension, caused, probably, by the fire; and that that tension is caused either by an incrustation on the inside, or by the water being driven away from the surface, and the sheet becoming heated. To test this I had a square piece of steel plate, about five-sixteenths of an inch thick and twelve inches square, planed off accurately, and then submitted to a heating process. I heated it to a cherry red, and then let it cool, and found that the contraction was very slight. I repeated that several times, and each time the contraction was slightly increased. I then arranged it so that I could heat a strip of the plate four inches in width and of the whole length of the plate. I then found that the contraction was very great, running up to about one-sixteenth of an inch. Before I got through with several different heatings, running from five to eight hours, I shortened the sheet over one-fourth of an inch through the center. This satisfied me that contraction was the cause of the rupture. But the cause of that *contraction* is left in uncertainty. On the eastern end of our road we have clear limestone water. There is no mud resulting from its use, but there is a very heavy incrustation. On the western end of the road we have surface water. There is a great deal of mud, but very little incrustation. When the boilers are cleaned out regularly the mud comes off down to the iron, and on that end of the road we have very little trouble with steel fire boxes; but on the other end, where the incrustation takes place, we have a great deal of trouble. I think it is largely due to the fact that the incrustation prevents the water having access to the sheet, and it becomes unduly heated, and contraction results. Any disturbing cause tends to produce a fracture, as the hammering on a stay bolt head. We have had some boilers give out from that cause, after standing in the round house a week without being fired up.

Mr. Flynn, Western & Atlantic Railroad—My experience has been right the opposite of that of my friend, Mr. Peddle. The road of which I have had control of the machinery for seventeen years has been very fortunate in the use of steel. We commenced its use in 1866 by putting steel fire boxes in seven new engines, and these are as good to-day as they were the day they were put in. It may be possible that they have had the same advantage that our Secretary says some of his fire boxes have had. They were wood-burning engines when first put into service, and burned wood for four years; then they were changed to coal-burning engines. None of our steel fire boxes have cracked, although I have heard a great deal about the difficulty with steel fire boxes. I built two of the boilers we are now using in our own shop; I thought that I would not attempt to anneal them, but would put them in as they were after the necessary work of flanging. It is true that I drilled instead of punching the stay bolt and rivet holes. The service that those two engines have had to perform has been about equally

divided between passenger and freight. Those fire boxes now, after a service of three years, look as well as when they were first put in. None of the plates have ever cracked. I at first dreaded the use of steel from hearing that it was attended with so many disadvantages, but I must say that my prejudice has been removed, and I am now in favor of the use of steel because I have experienced none of the bad results that have been described here. Our water is limestone on half of the road and freestone on the other; during a portion of the year a part of the road is very muddy. Shortly after we commenced the use of coal I had given orders that each engine should be thoroughly cleaned every two weeks, but found that one of the engines had gone past that time and the stay bolts had drawn out. I had no way to remedy the defect except to put in new stay bolts. I then introduced the system of having a book, under the charge of the round-house man, in which a record is kept of every time an engine is washed out. If I have any doubt about my orders having been carried out, I can learn by referring to this book just when each engine was cleaned. Mr. Hudson has stated that, in many instances, mud is allowed to collect in the boilers; that may be the case unknown to the Master Mechanic. I know an instance where we hired an engine to a connecting road, and it was returned to us after two months' service with a long crack across the top sheet seven inches below the flues. I thought it was something very strange, as it was the first engine belonging to the road that had ever given out in that way. I asked the Master Mechanic of the road whether he had cleaned the engine out regularly, and he said that it had been cleaned every two weeks. When she came back I examined her and found that she was clean in the lower part of the fire box, but when the boiler maker had cut out for the patch I found that the mud had accumulated until it came very nearly up to the flues, and in cleaning out before they sent the engine back they had forgotten to go up in the shell, and the mud was left there. Now, if I had not discovered that fact, I might, on examining the boiler and finding it clear of mud, have attributed the crack in the flue sheet to some defect in the iron; but, on thoroughly examining the matter, the cause of the crack in that flue sheet, which was of iron, was apparent. It had cracked because the mud had been allowed to accumulate to such a height and quantity that it had baked hard, thus causing the sheeet to become unduly heated and then to crack. I can not account for the fact that other roads have such trouble with their steel fire boxes when we have none. It will soon be nine years since we commenced the use of steel boxes, and in all that time we have not had any of them to crack. It may be owing to circumstances which are entirely outside of my knoweldge; it may be due to some peculiarity in the fuel or water; but this has been my experience, and I give it for what it is worth. I have had no difficulty, and therefore have no hesitation in saying that I am in favor of steel fire boxes.

Mr. Woodcock, Central Railroad of New Jersey—Our experience in the

use of steel conforms with the statements which have been made by most of those who have spoken on this subject. We have had both good and bad results. We are at present using steel in our furnaces exclusively, and that is evidence that we think pretty well of it, yet we have had some difficulties to encounter. We have a lot of ten-wheel engines which have been running for six years with fire boxes of steel one-fourth of an inch thick which have given excellent results, and are to-day apparently as good as any on the road; while we have others, passenger engines, using five-sixteenths of an inch steel, which have given us trouble. We have been careful to drill the holes and to anneal the sheets, and we are very careful that the rivet holes are just as they should be, yet with all this care we find that they *will* crack. This is a mystery that we can not solve. I would like to ask Mr. Graham for some information. In the year 1869 I was connected with the Dixon Locomotive Works, and built two engines there with steel furnaces, the side sheets of which were corrugated, and I would like to know what has been the result of the corrugation of those sheets, and whether it was of any benefit. The information may be valuable in connection with this subject.

Mr. Graham, Lackawanna & Bloomsburg Railroad—About sixteen years ago I suggested corrugating the side sheets. My experience for twenty years had been with anthracite coal-burning engines, and we had great trouble with the cracking of boilers, for anthracite coal is a very hard fuel for furnaces. It makes a fire so hot that it will melt a pig of iron as easy as butter. Our furnaces are from eight to nine feet long. I never had the opportunity to try corrugation as a remedy for the cracking until the time mentioned by Mr. Woodcock. The boilers to which I refer were the first that I made after I was in a position to carry out my own views. The boilers then made are still running and in good order. They have been in constant use for six years. I did not corrugate the whole of the side sheet. I put it in in two parts, connected by a longitudinal seam, and corrugated the lower half of the sheet which is opposite the fire. I have been building engines in that way right along for six years. I corrugate them about three-quarters of an inch. Three men will corrugate a sheet in half an hour. I bring the row of stay bolts at the top and bottom of the corrugations, and then straighten the edge of the sheet, which gives a straight seam with no more trouble than with a flat sheet. I have no trouble with the cracking of sheets since I commenced to corrugate. We use iron exclusively and have had very good results. I have had no experience in the use of steel.

Mr. Clark, Lehigh Valley Railroad—I am connected with a road that uses anthracite coal for fuel, and on which we have been using steel fire boxes for ten years. We have locomotives with steel fire boxes with grates seven feet long. The side sheets are made in two parts, but are not corrugated. We have never had a single sheet to crack. We have about twenty-five locomotives of that class running at present. There was an engine sent for me to repair from the upper part of ur road, where the

water is very bad. She had a steel fire box, and when we undertook to clean it out, we found an incrustation extending up twenty-two inches from the bottom, and it was so hard that we could not cut it out with a chisel. If I had not thought the fire box was burned I would not have taken it out, for there was not a crack in it.

Mr. ROBINSON, Great Western Railroad—In the year 1853, the Great Western Railway received a number of engines from Stevenson's Works, in New Castle. One was called the "Ixicon." A few years afterward that engine came to the shop, and we found that the box was filled from fifteen to eighteen inches from the bottom with a hard mud resembling rock. We had to take the plate out and cut that off, and we found the plate changed in its nature—the Yorkshire had become cast iron. It was so hard that when struck across the rail where the engine was standing it broke into pieces just as thin cast iron would. That shows that the nature of the iron had become changed, and I think that nothing else could be expected from such treatment as that iron had been subjected to—a solid material on one side of the sheet and a fire on the other. The iron had baked and baked until it became carbonized, and in that way became like cast steel. I would not say that the reason members are having trouble with their steel fire boxes is because the fire boxes are not properly cleaned; but I think that if they were kept *perfectly* clean, the percentage of cracked boxes would very materially decrease. When a fire box cracks and you examine the boiler and find it perfectly clean it does not follow that the fire box has not been very dirty at some previous time when the injury was done. The injury might not have been apparent until the mud was removed. It may often be the case that you can not discover a defect until after the cause of the injury has been removed.

Mr. PEDDLE, Terre Haute & Indianapolis Railroad—I am sure that the boilers on our road are thoroughly cleaned. We have a head of water equal to thirty pounds to the inch, and we use that water with a three-quarter inch nozzle, and it knocks out the mud and scales just as a jet of steam would. Our boilers are cleaned as well as they possibly can be once a week on the west end of the road where the mud is, and about once in two weeks on the end where the incrustation takes place. As I said before, the mud does not trouble us any. The incrustation which it seems almost impossible to get off is, I suppose, the source of all our trouble.

THE PRESIDENT—It has been our custom to have a recess during the day, and if there is no objection we will now take a recess of ten minutes. Before we do so, however, I wish to state to the members that this hall is kindly donated to us by Mr. Peter Cooper, and the trustees of the Cooper Institute, and one of the conditions of its use is, that there shall be no smoking in the building. The members will please bear that restriction in mind. During the recess another opportunity will be given for those who have arrived since our Convention assembled and are eligible to membership to sign the

constitution. The Committee on Assessments will be prepared during the recess to receive the assessment of members.

The Convention then took a recess of ten minutes.

On re-assembling, Mr. Lauder, of Northern Railroad of New Hampshire, moved that the further discussion of the report on the "Best Material, Construction, Operation, and Management of Locomotive Boilers," be postponed and made the special order for Wednesday at 11 o'clock.

Motion carried.

The Committee on Finance presented the following report:

Report of Finance Committee.

To the American Railway Master Mechanics' Association:

GENTLEMEN—The Committee appointed to examine the accounts of the Secretary and Treasurer respectfully beg leave to report that they have performed that duty, and found them correct.

J. W. PHILBRICK,
THOS. KERR,
WM. McALLISTER, } *Committee.*

On motion, the report was accepted.

THE PRESIDENT—The next business in order is the report of the Committee on the Purification of Feed Water. The Committee consists of Messrs. Towne, Sellers, Elliott, Wilson, and Faries. The report is in the hands of the Secretary, who will read it.

To the American Railway Master Mechanics' Association:

GENTLEMEN—In compliance with the usual custom, your Committee issued the following circular:

Purification of Feed Water.

To ——— ———, M——— M———:

DEAR SIR—The Committee appointed at the last Convention of the American Railway Master Mechanics' Association to investigate the above subject, and ascertain the most approved methods for the treatment and improvement of feed water, by chemical or mechanical means, and for the prevention of incrustation, beg your earnest consideration of the following questions:

1. What means, if any, have you adopted for the improvement of feed water for locomotive use?

2. Can you suggest any method of depuration that would, in your opinion, improve the water on the line of your road?

3. Do you recommend the use of rain and surface water, wherever it can be gathered in reservoirs or otherwise?

4. Have you tried thoroughly any means to remove old formations, and to prevent the accumulation of new, and what do you recommend?

5. What boiler compound, if any, do you recommend for the removal and prevention of incrustation?

The Committee earnestly request the benefit of your experience in any experiment conducted by yourself, or others under your observation, and all information upon this subject given in detail will be thankfully received and appreciated. We especially request the contribution of specimens of incrustation for analysis, which please label with name of road, and mileage of engine in which they accumulated; also, please send, if possible, analysis of the water used in engines on your road, name of place from which it was taken, and its effects upon your boilers. Respectfully,

H. A. TOWNE, *Northern Pacific Railroad*,
COLEMAN SELLERS, *Philadelphia*,
H. ELLIOTT, *Ohio & Mississippi Railroad*,
W. WILSON, *Chicago, Burlington & Quincy Railroad*,
H. V. FARIES, *Atchison, Topeka & Santa Fe Railroad*,
} *Committee.*

Please address your reply, not later than February 15, 1875, to—

H. A. TOWNE, St. Paul, Minn.

The questions contained in the above, and other printed circulars seem to cover all the ground necessary to a final solution of the question, so far as it is within the province of the Committee to encourage experimental research. To enable them to gather reliable information growing out of any experiments, a special interest should be manifested on the part of the members to contribute the result of their experience touching any suggestions contained in the interrogatories, otherwise but slow progress can be expected which may result in any immediate benefit to railroad companies. Your Committee is familiar with experiments that have been going slowly on for the past two or three years in the way of gathering and storing rain and surface water, which has been the means of a decided im-

provement in the feed water at such places, but no direct information concerning said experiments has reached us from the members who are employed upon these lines, neither have they replied to the circular. We have a communication from Mr. Reuben Wells, of the Jeffersonville, Madison & Indianapolis Railroad, stating that they have changed three water stations during the last Winter, taking creeks and surface water in lieu of that from wells, which contained large quantities of lime and other incrustating substance, and they have already noticed a marked difference in the performance of their engines in that locality, finding, especially, much less trouble with leaky flues and joints. He knows of no other plan at present more practicable than that of using rain and surface water wherever it can be collected, and creek and river water at other places.

We also have the following from Mr. Charles Peddle, of the Terre Haute & Indianapolis Railroad: "On the East Division of this road, extending from Indianapolis to the State line, the water used by the locomotives is mostly obtained from wells or springs, and the Wabash and White Rivers, which, in their low stages, derive most of their water from springs which rise through their gravelly beds, and we are much troubled with incrustation on the fire box plates and tubes of the engines on that division. I have had this deposit analyzed at different times, and find that the sulphate of lime and magnesia are the chief ingredients. On the Western Division, extending from the State line to East St. Louis, the water is mostly obtained from ponds or reservoirs, supplied by surface drainage, and dependent entirely on the rain-fall. The water, however, holds the clay soil in solution, and is seldom entirely clear; hence the boilers require frequent washing, say after running from seven hundred to nine hundred miles. If this precaution is taken, and the leg of the fire box and the bottom of the barrel is kept free from mud, very little incrustation takes place, and there is a marked increase in the durability of fire boxes and tubes over those on the other division. I am of the opinion that money is better invested in providing an ample supply of surface water, than in making a chemical laboratory of the boilers, endeavoring to soften hard water before using it."

The same is equally true in the experience of other roads, yet we have this assurance from only a few Master Mechanics. It is exceedingly difficult to furnish reliable statistics upon such a subject

without the co-operation of those who are in possession of valuable information pertaining directly to the leading features of the matter under consideration. There are now six hundred Master Mechanics in this country, representing nearly as many (five hundred and ninety-nine) distinct corporations, having, in all, over seventy-two thousand miles of railroad, and about twenty thousand locomotives, distributed over so large a territory that any other means than the circular system of concentrating so vast a scope of varied experience would utterly fail; hence it is that any experiments embracing information tending in the least degree to mitigate this evil should be available. The fact that this troublesome and expensive annoyance is decreasing, from year to year, is sufficient evidence that railway managers are moving in the right direction; and as they become better acquainted with the matter, and all its serious consequences, incrustation will then, we think, become the exception instead of the rule.

The question, as it now appears, is so well defined in former reports that it needs no further argument to prove that the purification of feed water, before its introduction into the boiler, is the only true remedy. There can be no doubt that the reservoir system, as recommended last year, is a most admirable method of providing suitable water for railroad purposes, but it must be borne in mind that either reservoirs or ponds should be provided with convenient means for disposing of the mud by settling or filtering. The water will then reach the boilers comparatively free from incrustating substances, so that washing or scaling will seldom be found necessary. At places where reservoirs are impracticable, and wells have to be depended on, a late and new process of tank depuration can be cheaply and successfully employed. During the past three years Prof. J. A. Sewall, at the instance of the chairman of your Committee, has devoted much valuable time to the study of this subject, with a view thereby to ascertain the simplest and cheapest re-agent, which would effectually precipitate in cold solutions, lime, magnesia, alumina, iron, and other incrustating substances. As the result of his labors he has produced what he terms "ammoniated pinate of soda," as being best adapted to all the requirements of the case. It will effectually precipitate all the salts of lime, magnesia, iron, and alumina, at a cost so trifling that it would seem at once to recom-

mend itself for practical use. The extra expense attending the use of this agent would be the erecting of an additional tub, so that two might be employed in the process of purification, thus drawing the purified water from one while the purification is going on in the other. The tubs should be connected by means of two valves, so that the water can be shut off from one while it is drawn from the other, alternately.

The sediment may be allowed to accumulate till it rises to a level with the outlet, then mud valves, suitably arranged in the bottom of the tub, must be opened, and the sediment washed out. The time required for purifying, after the introduction of the re-agent, is from twelve to twenty-four hours. A specimen of the water to be operated upon must first be analyzed, then the re-agent can be prepared to suit the case, and the quantity introduced continuously with the supply from the pump, the process being so simple that attendants usually employed at water tanks can manage it without the possibility of a mistake.

In an experiment made on the Northern Pacific Railroad by the chairman of your Committee, sixty thousand gallons were operated upon, with quite satisfactory results; the well known tests for lime, magnesia, iron, alumina, etc., being applied to the purified solution without finding a trace of either. The expense of this re-agent in the treatment of the hardest water will not exceed one-half cent for every fifty gallons, or, as Prof. Sewall stated, about one-half cent per mile run. The expense due to incrustation, according to careful calculation made by your Committee in their report in 1872, will amount to about seven hundred and fifty dollars a year to each engine, or to two and one-half cents per mile (allowing each engine thirty thousand miles). If, after a further investigation of this new process of tank depuration, it should still be found practicable, inexpensive, and efficient, as we believe we will, your Committee will have accomplished more than it had reason to expect. We are, at any rate, inclined to feel greatly encouraged over the progress that has been slowly, but surely, made toward a final solution of this vexed question. Rain and surface water are of the first importance to railway companies; but, if that can not be had, the next best thing is to purify, before using, by any means that may be found to answer the requirements of the case at a reasonable expense. Chemical

compounds for removing and preventing incrustation are still in the market, but they are not in a single instance recommended by the members of this Association (this year), and we desire to add, if they are to be employed at all, the most reliable articles should be selected and used with the greatest care. For authority concerning harmless articles operating inside of boilers, see "Zells' Popular Encyclopedia on Incrustation." Among the cheapest articles that have been used is carbonate of soda, the common soda of commerce. The introduction of soda into a boiler in considerable quantities has a tendency to produce priming, hence the danger attending its earliest employment is sometimes productive of more harm than the good derived from its judicious use. The best method of introducing the soda is to dissolve it in the tank, and pump it into the boiler continuously with the feed. The usual quantity varies from one to two and a half pounds per day, according to the quality and quantity of water evaporated. The use of soda must be followed with frequent blowing off and thorough washing, otherwise the settling of large quantities of sediment will be found injurious, if not dangerous.

The "stealite talc," spoken of in the report of last year, is a harmless natural production, hence it is free from those objectional features usually attributed to chemical preparations. We are in possession of flattering accounts of the efficiency of this article in preventing and removing scale without any deleterious effects. We intend to make a further trial and investigation of its merits.

The condensing apparatus referred to in our report of 1873 is still in successful operation at the shops of the Hannibal & St. Joe Railroad. Recent accounts concerning its performance strengthen the theory that surface condensation is practicable as a means of preventing incrustation without injury to boilers. After four years' service the above boilers are not, so far as has yet been observed, injured in the slightest degree. Their internal surface shows a thin coating of white hard scale, probably the result of the introduction of from twenty to twenty-five per cent. of the natural water to make up the deficiency arising from a lack of perfect condensation. It is claimed by some authorities that the water of condensation—in other words, very pure, or distilled, water—acts injuriously on the plates; but we are not aware that such has been the result except with salt water on ocean steamers. If fresh water, under the same treatment, should

be found deleterious, then the proof is clear that the intervening thin coating of scale between the iron and the water has effectually protected the above boilers from deterioration. These boilers seldom get dirty, the rule being to blow them out once a week, and wash them once in three or four months. From this experience it may be safe to conclude that, wherever there is a sufficient supply of water, this style of condenser can be safely and economically employed.

Your Committee desire to urge the importance of a more general use of the mud drum for locomotives, as recommended last year, believing a proper use of it has much to do with keeping boilers free from a troublesome collection of sediment. The mud valve should be fitted in the most substantial manner, with connections within the reach of the engineer; and frequent blowing off, say several times a day, should be observed, otherwise little or no benefit will be the result. It has been noticed that if the head, or cover, of the drum be made conical, it facilitates the removal of the mud as fast as it collects in the drum, the tendency being to run out of its own accord. If, however, the valve should not be opened for several days, the sediment will become so hard that blowing off will not remove it, but simply open a hole through it. The accumulation will then increase till the cover is removed, and a thorough washing instituted.

Blow-off valves, usually placed in leg of locomotives' boilers, are seldom opened while the engine is at work, for the reason that they are not always fitted with suitable connections and placed within the reach of the engine men. The prevailing impression that any kind of a blow-off cock is *good enough*, is so serious a mistake on the part of engine builders and Master Mechanics that it should meet with the severest condemnation. Every time a mud valve is opened under pressure, it produces a violent circulation of the water throughout the entire boiler, which changes the location of the deposit, and sets it whirling till it finds its exit through the open valve. If similar artificial means could be devised to maintain a rapid circulation in locomotive boilers, incrustation would not form to any considerable extent, providing frequent blowing off was regularly observed. To prove the efficiency of this principle, we would refer you to the upright boilers having pendent water tubes suspended from the crown

sheet into the open fire box, and provided with small circulating tubes inside of them, extending down to within about three-fourths of an inch of the lower end of the large tubes, which are made water tight by the insertion of water plugs. The intense heat on the outer surface of the large tubes causes the water to ascend within the annular space, between the inner surface of the large tube and the outer surface of the small one, while at the same time the cold water descends through the small tube, and thus maintains a constant and rapid circulation.

The chairman of your Committee has observed, with no little curiosity, that incrustations do not form in tubes arranged in this way. It is not probable, however, that any means so effectual can ever be successfully employed in the locomotive boiler; hence we must return to our former conclusions, which seem to strengthen as our investigations continue, and that is to purify the water before its introduction into boilers, first, by using rain and surface water, properly filtered; and second, by tank depurations, as proposed.

In conclusion, we have the honor to submit, in the appendix, Prof. J. A. Sewall's paper on "The Purification of Water for the Use of Locomotives and Other Steam Boilers," to which we invite your careful attention and consideration.

Respectfully,

H. A. TOWNE, *Northern Pacific Railroad*,
COLEMAN SELLERS, *Philadelphia*,
H. ELLIOTT, *Ohio & Mississippi Railroad*,
W. WILSON, *Chicago, Burlington & Quincy Railroad*,
H. V. FARIES, *Atchison, Topeka & Santa Fe Railroad*,
} *Committee.*

H. A. TOWNE, *Chairman.*

On Purification of Water for the Use of Locomotives and Other Boilers.

H. A. TOWNE, *Chairman Committee, etc.:*

In accordance with your request, I beg leave to submit the following:

I have no doubt that, in order to prevent incrustations, the materials which produce, or form, the crust, or scale, should be removed before the water is admitted to the boiler. This plan is theoretically, and I believe will be found to be practically, the true

one. My own opinion touching this matter may have little weight, but I believe that a majority of the members of your Association, as well as chemists of high authority, are of the same opinion. I here indicate where facts and opinions bearing on this matter may be found: Maspratt, Vol. II, pp. 1087, 1088; Encyclopedia Britannica, Vol. XX, p. 635; New American Cyclopedia, Vol. XX, p. 59; Annals of Scientific Discovery of 1859, p. 231, by Medlock; of 1868, p. 205, Booth; and of 1870, p. 215, Dr. Gunning.

Incrustation, for the most part, consists of the salts of lime and magnesia, the former constituting in a majority of cases ninety-five per cent. of the scale formed. Any chemical agent introduced into the boiler, at best, only changes the form of these salts of lime, but leaving them insoluble salts of lime still. These may not so readily form scale, or they may be removed with less difficulty than the salts deposited directly from the water. The evil is to some extent mitigated, but not cured, certainly not prevented. "Prevention is better than cure."

Several well known re-agents will remove these salts of alkaline earths, but most of them are objectionable, either from their cost, or from the fact that the depuriated water would contain certain chemicals that would attack and injure the iron. What is required is a re-agent that will completely remove the alkaline earths, etc., from cold solutions, that will not in any way injure the metal with which it may come in contact, and the cost of which will make its use profitable; or, in other words, render the cure cheaper than the endurance of the evil. Oxalic acid, or the oxalate of ammonia, precipitates in cold solutions lime and magnesia as insoluble oxalates. If, however, an excess of the re-agent be added, this excess would injure the metal of the boiler. Hydrate of lime and chloride of barium will effectually remove the salts of lime, etc.; the former removing or precipitating the carbonates, the latter converting the sulphate of lime into the insoluble sulphate of baryta, which would be precipitated, and also the soluble chloride of calcium. If there were no other objections, the difficulty of adjusting the strength of the lime solution, and the cost of the chloride of barium, would prohibit the use of these re-agents. Hydrate of lime and acetate of lead would act as well, the former precipitating the carbonates, the latter con-

verting the sulphate of lime into the insoluble sulphate of lead, which would be precipitated, and also the soluble acetate of lime. The cost of depurating water by either of the above named plans would be from two to three cents per mile, or for fifty gallons. I speak of such water as is used generally by railroads in the Mississippi Valley.

I have conducted many experiments, with various chemical reagents, to find something that would answer all the requirements, and I am prepared to recommend the ammoniated pinnate of soda as best adapted to the end. This agent precipitates from cold solutions all the salts of lime, magnesia, iron, and alumina usually found in feed water, leaving nothing in the water that can in any way injure iron or other metals; but, on the contrary, will prevent oxidation. The cost would not exceed half a cent a mile, or forty gallons. By this re-agent the carbonates of lime and magnesia are converted into insoluble pinnates and precipitated. The sulphate of lime is converted into the insoluble pinnate, leaving in the water the perfectly soluble and harmless carbonate and sulphate of soda. The ammonia facilitates the precipitation of the iron and alumina; moreover, any impurities that may be suspended, not dissolved, into the water will be to a great extent carried down with the precipitates. In fact, the presence of any perfectly soluble saline body in water tends to throw down all suspended matter. See Hunt's Chemical and Geological Essays, p. 10; or, Proceedings of Boston Society of Natural History for October 15, 1873, and February 18, 1874; also, Humphrey and Abbott's Report of the Physics and Hydraulics of the Mississippi River (Appendix XI). With this re-agent I have succeeded in depurating water at a cost of less than half a cent per fifty gallons.

The use of this re-agent for the purpose above named would require extra tanks; but as this matter belongs to the mechanical rather than the chemical department, I need make no suggestions, believing, however, that some plan may readily be devised so that this method of depurating can be made both practicable and profitable.

Permit me to extend to yourself and Mr. Jackman, of the Chicago, Alton & St. Louis Railroad, my hearty thanks for assistance and

many valuable suggestions during the time I have been making these investigations. Respectfully,

J. A. SEWALL, *Illinois State University.*

FEBRUARY 9, 1875.

Since writing the report we have received the following communications from Messrs. J. H. Setchel, of the Little Miami Railroad, and H. V. Faries, of the Atchison, Topeka & Santa Fe Railroad, both of which we respectfully submit.

Mr. Setchel's views are entirely consistent with those of your Committee, who are also prepared to recommend the surface blower, especially in alkali regions, where the sediment assumes a floculent amorphus form (producing priming), which can be blown off from the surface.

Mr. Faries' letter contains the result of some curious and important experiments that evince assiduous prosecution, which entitles the gentleman to much credit.

H. A. TOWNE, *Chairman Committee.*

Purification of Feed Water.

H. A. TOWNE, Esq., *Chairman of Boiler Committee*:

DEAR SIR—At this late date I have at last found a little time to answer some of the questions as far as possible, and will be quite brief.

I have been waiting the result of a mechanical experiment that I put into operation last April, which was to set the tubes one inch apart so as to admit of a greater body of water between them. I took Engine No. 7, of Taunton build, belonging to this Company. The barrel of the boiler is forty-six inches in diameter, with eleven feet six-inch tubes, two inches outside diameter, gauge No. 13. This boiler had, when put upon the road in 1871, one hundred and thirty-five tubes, and continued to run with that number until April, 1874, during which time it was necessary to remove the tubes four times, all owing to the immense deposit between the tubes; during this time the back tube sheet became blistered and cracked in many places, and consequently had to be replaced with a new one.

I will here mention that the original sheets were Sligo iron, and were replaced with the same kind. The bridges between the tubes

were five-eighths of an inch wide one way, and eleven-sixteenths of an inch the other. The tubes occupied all the space there was in the back sheet, some of them within one-half of an inch of the flanges, and before I laid off the tube holes in the new sheet I made the calculation as to how one hundred and five tubes would compare with one hundred and thirty-five of the same size, and found twenty-two and one-half per cent. less tube heating surface, but found the boiler would contain, counting the water at the level of the upper side of the top row of tubes, eight cubic feet or five hundred pounds more water than it did with the original number of tubes. This I considered once heated would resist the feed water and be about equivalent to the twenty-two and one-half per cent. reduction of the tube surface. From this data I made the experiment by removing the front head and replacing it with a new one to correspond with the new back sheet wherein the tubes were placed one inch apart. But before proceeding farther, I will make mention here that no engine on this road running between Emporia and Wichita, a distance of one hundred miles, can run over ten thousand or twelve thousand miles without having at least one-half or all of the tubes removed in order to clean out the scale to prevent leakage and save fuel. All the freight engines will commence to leak in about twenty days after being put on this division, even with an entire new set of tubes if they draw heavy trains—say thirty-five loaded cars, and the grade does not average over ten feet to the mile, except five miles, which is forty-five feet to the mile, over which all trains double. All of the water between Emporia and Wichita is strongly impregnated with sulphate of lime, commonly known as gypsum, mixed with carbonate of lime, salt, or magnesia. The sulphate of lime does not allow the sheets to remain as cool as is the case with good water, and the consequence is that with a heavy fire the metals are expanded too much, and as soon as the throttle is shut off, and the fire slackened, the flue sheet finds its original shape, while the tubes have been permanently contracted and can not return with the sheet to their original or perfect setting. Steel or iron sheets seem to act about the same in this respect. All this difficulty led me to believe that less tubes and more water space would obviate this trouble somewhat, and I am pleased to say that my expectations have been fully realized, as I am fully prepared to give the performance of Engine

No. 7, compared with the same class engines with forty-eight-inch barrel, while Engine No. 7 has but forty-six inches; but in all other respects the engines are all alike, which difference I think is against Engine No. 7.

But we will let the performance sheet show for itself, which is kept by my clerk, who knows nothing about the experiment except to make out the reports, especially the coal tickets which are handed him at the end of each month by the coal agent; all of which I consider an important test. Engine No. 7 has not been favored in any way since the experiment began.

The train sheets show that Engine No. 7 did not lose a trip from the time she was put on the division where there is so much trouble with the water. While the same class of engines running on the same division had to have more or less work done to the tubes every week, and would not stay tight twenty-four hours at any one time, Engine No. 7 run for ten weeks without leaking a particle when fired up; but, like all other coal burners, sapped a little when cold. Engine No. 7 was not in constant use from the time she received the new sheets, with only one hundred and five tubes, on account of a falling off of business, but had run fifteen thousand miles up to the 7th day of January, 1875. At this time she became badly limed up and began to give some trouble for steam the last week in December, 1874, but was still making her regular trips at the time I laid her up for the purpose of removing the tubes. I found the space between the tubes about one-half closed up with hard scale deposit, but still water space sufficient to keep the metals from perishing with the flames, while two other engines taken in at the same time, with tubes only eleven-sixteenths of an inch apart, were solid from one-half to two-thirds the perpendicular distance of the whole tube surface, which cut off fifty per cent. of the tube heating surface and only left about sixty-eight effective tubes and less hot water to resist the feed water.

All of these difficulties being constantly before me, I made up my mind that I must do something to avoid so much boiler-work (as I have never tried any boiler purger that would do any good), and I am satisfied that less tubes, or to place them as far apart as will possibly answer for generation, is the best thing that can be done for this line of road. Some persons have asked the question: "Why

not make a still greater reduction in the number of tubes?" I would so recommend if the tubes were two and one-half or two and three-fourth inches in diameter, which would form a more perfect combustion. I do not hold that this mode of setting tubes, as I have them in Engine No. 7, would be the best thing for general purposes, or for lines that have good water. I have also left off the crown bars on some of the engines on this road, on account of so much scale formation, and suspended the crown sheet to the wagon top with eye bolts and links and pins, which stands all right and is much better about removing the scale through the cleaning plugs, which are placed on the sides and end of the boiler above the crown sheet in the ordinary way; but I have not yet learned any way to prevent the formation of scale in boilers on this road, or to remove it otherwise than by mechanical force. This Company has bought large quantities of boiler purges within the last three years, but none of them would answer the purpose set forth. I have tried J. Lavos' Compound, of Wyandotte, Kansas, which seemed to do the work for the first few weeks, after which it seemed to assist in forming scales around the fire box that the heat could not drive off, which is done more or less without the use of this compound, and falls to the bottom where they can be broken up and taken out. I have tried the Houghton Compound, of New York, and have a large quantity of it on hand at present, which threw two of our best engines out of the service in one day. It caused them to leak in every tube; and in many places the rivets and caulking commenced to leak so much that it was impossible to get them out of sight of the shops with half a train. I laid them in and did the necessary repairs, and found the scale as solid as though no compound had been used. I got quite a lot of the "Excelsior Boiler Compound," which is made in Cleveland, Ohio, but it did not do the work any better than the others; but I will give it credit for not making the boilers leak. I have tried coal tar to a considerable extent, but found it entirely useless; it would settle in the leg of the boiler and remain there as pure as the day it was put in. I also tried petroleum oil, and have had as much as fifteen gallons in one boiler at once, but it did not effect the formation in any way that I could discover nor produce foam.

Blocks of zinc were highly recommended, by suspending them to the stay bolts in different parts of the fire box. I cast them to

weigh about one pound each, and put from four to six of them in each boiler, and I found in six days the acid in the water would entirely decompose the zinc so as to leave no trace of it, while the scale formation built up the same as usual. The best thing I tried was the loose black prairie soil, but it produced too much foam and makes it difficult to even run an empty engine, and it will not remove the old deposit, but will, in a great measure, prevent the formation in a clean boiler, and all fermenting substances seem to do the same thing, such as beef tallow, malt, starch, ship stuff, etc.; but all such things are impracticable and hardly worth mentioning, and scale formation in boilers on this line is as much master to-day as it was five years ago.

I think, if the Association intends to prosecute this matter of holding the sediment in solution, the best way would be to elect two men, one to be a practical Master Mechanic, and the other a practical chemist, and pay them for their full time so they could go to the different parts of the country and gather all the information they could, and get samples of scale and water, and give the Association the benefit of the various tests. I have no time nor facilities to experiment with such matters with any satisfaction and attend to my duties, as I am expected to at all times; neither do I believe that any Master Mechanic can devote time sufficient to ever gain the requisite information. As to the best way of disposing of bad water for locomotives, especially in a country where there is no other kind to be had, I would most earnestly recommend the use of rain water at all times; for, in a rainy season along this line, there is but little trouble with leaky tubes, and the sediment is held in solution and is easily washed out, while the hard formation on the tubes and fire box is more porous and more readily permits the water to come in contact with the heating surface, which causes the engines to steam much better with less fuel. But in this country there is a difficulty in using surface rain water, owing to the whole earth being strongly impregnated with alkali, which is taken up with rain water, and causes the engines to foam more or less. This Company put up a water station at a point that usually fills with rain water every season; but it has been abandoned partly on account of an insufficient supply, and because of its foaming so badly. I do not think that puddling, or rock bottom and walls; would improve the water or

free it from alkali. I fully expected to be able to furnish you with an analysis of the water on this line, but I could not do so without giving it my personal attention, and the consequence was that I had to give it up, but will send you some of the common specimens, such as I have to deal with every day, more or less. The total mileage for engines running on the road for 1874 was a little less than eight hundred thousand miles, and I was compelled to remove nearly twenty-five hundred tubes, and a proportionate number of crown bars, and the same thing must be done this year. I am inclined to think that as the country becomes more settled and cultivated the less rain fall there is to supply the streams, owing to the natural evaporation caused by the tillage of the ground, and the feed water for boilers is much stronger impregnated with the salts of the earth than it was some years ago, as the formation is more and more rapid every year. The only method that would improve the feed water would be to heat it to two hundred and fifty degrees and allow it to filter, and thereby take out the impurities before using it in the boiler. But this seems to be so expensive that its practicability is much doubted and slow to begin; but it is a sure remedy in all countries, and will cost less per annum than coal and boiler makers under the most economical management.

The following is a statement showing performance of Engine No. 7, as compared with two engines of same capacity, running on same division during four months, viz.: September, October, November, and December, 1874:

No. of Engines.	Time running.	Miles run.	Tons Coal used.	Miles run per Ton.
7	Four Months.	9470	460½	20$\frac{56}{100}$
8	Four Months.	8795	436½	20$\frac{14}{100}$
15	Four Months.	9545	445	21$\frac{45}{100}$

Most respectfully submitted,

H. V. FARIES, *M. M. Atchison, Topeka & Santa Fe Railroad.*

MARCH 16th, 1875.

Purification of Feed Water.

H. A. TOWNE, Esq., *Chairman of Committee on Feed Water:*

DEAR SIR—The management of this road have, within the last few years, made strenuous efforts to improve the feed water of locomotives, and with marked success. This, however, only extends to the changing of water stations from springs of hard water to making use of creeks and surface water available along the line. Within the last few years six of these stations have been changed, and the result has been that, where it was at one time considered an impossibility to burn coal, and where it was actually tried and abandoned on account of the difficulty of keeping flues and fire boxes tight, we now have as little trouble as we formerly did in burning wood. In fact, we have as little trouble as it is desirable to have with flues, they lasting from two to three years without any difficulty, comparatively speaking.

We have within the last week taken out a set of flues that have been in use forty-two months, and the engine has run during the time one hundred and forty-nine thousand eight hundred and fourteen miles, or one hundred and fourteen miles for every day in the whole time. In removing the flues we found considerable sand and sediment in the vicinity of the checks, but not as much hard scale as we found in one year previous to changing our water tanks. In the opinion of the writer, if roads would make use of the *best* water along their lines, it would go far toward mitigating this great evil of incrustation. I know of no method of purification that is practicable for the amount of water that is required to operate a first-class road.

I do unhesitatingly recommend the use of reservoirs where it is practicable to make them. I have tried many of the inventions for removing and preventing scale, but have found nothing that, in my opinion, will so effectually answer the purpose as a good surface blower. In my last communication to the Committee on this subject you were notified that "Hays' Galvanic Battery" was being tried on three engines on this road, and that a report would be made in regard to its workings. I can not see that any good results have been accomplished by its use. The scale was fully as heavy on the

engines with the attachment as on those without, and I could not, therefore, say any thing in its favor. More good has been accomplished with us in the way of preventing scale by using soft water, than any other. Yours respectfully,

J. H. SETCHEL.

MARCH 29, 1875.

On motion of Mr. Sedgley, the report and letters were accepted and ordered to be printed.

THE PRESIDENT—Our sessions usually last from nine o'clock in the morning until two in the afternoon. It is now past three o'clock. I wish to state to the members that the merchants and manufacturers of New York have extended an invitation to us to attend the Fifth Avenue Theater this evening; on Thursday afternoon to a drive in Central Park, and on Friday to go on an excursion on the steamer Long Branch. The invitations have been accepted by the Supervisory Committee. Tickets for the theater this evening will be found in the Committee Room at the St. Nicholas Hotel. The Committee have also extended an invitation to our ladies to a drive on Wednesday afternoon, and to attend a musical entertainment in the evening.

On motion, the Convention adjourned to nine o'clock Wednesday morning.

SECOND DAY'S PROCEEDINGS.

The Convention met at nine o'clock Wednesday morning, May 12th, President Britton in the chair.

Mr. HAYES, Illinois Central Railroad, moved that a committee of five be appointed by the President to select and recommend subjects for discussion at the next Convention.

Carried.

THE PRESIDENT—I will appoint on that committee, Messrs. Wells, Boon, J. W. Philbrick, Flynn, and McAllister. If any members have subjects that they would like to have discussed at the next Convention, they will please put them in writing and hand them to the Committee or to the Secretary.

Mr. ROBINSON, Great Western of Canada—I move that a committee of three be appointed by the President to select a place of meeting for the next year.

Carried.

THE PRESIDENT—I will appoint on that committee Messrs. Sedgley, Eastman, and Bushnell. I would state to the Convention that during the last two months there has been some correspondence between the Supervisory Committee and parties who are to test some steel and iron axles in this city this afternoon, at four o'clock; and that a committee consisting of Messrs. Hayes, Forney, and Sellers, has been appointed to attend. Members that would like to see the test are invited to be present. It is probable that we shall have to hold an afternoon session, and I hope that the members will not lose sight of our Convention in their anxiety to witness the test. Yesterday, at the close of the session, we had finished reading the report on the "Purification of Feed Water;" is it your pleasure to enter upon the discussion of that report at this time?

Mr. SELLERS, of Philadelphia—I move that we now make that report the subject for discussion.

Carried.

THE PRESIDENT—Discussion on the report of the Committee on the "Purification of Feed Water" is now in order.

Mr. SELLERS, of Philadelphia—I suppose that you are all well aware that many of the reports have to be prepared by the Chairman of the Committee, because the members are separated by long distances. I wish to speak in praise of the labor that has been performed by the Chairman of this Committee, Mr. Towne. I understand that the greater part of the work has been done by him, and it has certainly been done in a very thorough manner. But, at the same time, one dislikes to have their name appended to a report that they have not had an opportunity to read before it is presented to the Convention; although my name is attached to the report, I never saw it until it was read yesterday. I do not say that I have any objection to it in the main, but there are one or two statements contained in it which might place me in a wrong position without some explanation. I am represented as having stated that water distilled from sea water had an injurious effect upon boilers. That is not what I intended to say, for such is not the fact. I said that fresh water used with surface condensers on ocean steamers, unless they admitted salt water to it, so as to produce a slight scale, was detrimental to a boiler. It is not the use of the salt water that is detrimental. The boilers of those steamers that supply themselves with fresh water on starting, and do not allow the use of salt water, are injured in a single trip, because of this fresh water being used over and over again. Some think that it is the tallow or something else that enters into the cylinders and produces an acid that is deleterious to the boilers. But be that as it may, the use of distilled fresh water in ocean steamers with surface condensers has been entirely abandoned, and they now inject a certain quantity of salt water into the boilers so that a scale of slight thickness shall be produced. They find from experience that the presence of this scale tends to prevent any deleterious action on the boiler. The Committee have spoken of a sub-

stance introduced by Professor Sewall for the purification of water before it enters the boiler. I know nothing about this chemical substance, nor how it will act, and, therefore, only take the statements upon the faith of Professor Sewall's high reputation. It is doubtless exactly what he represents it to be, but I think something else is needed beside the mere mixture of certain chemical ingredients in the water—a mechanical action is also needed. There is a large chemical house in Germany selling a preparation to the railroads of that country for the purification of water. Doctor E. DeHain, a manufacturer of chemicals in Prussia, has published a paper on the subject in which he states that the mere mixture of a definite quantity of a chemical substance in water is not the only thing needed. Agitation is required to secure the best results. The stirring of the water at the water stations, by some mechanical arrangement, would present an almost insurmountable difficulty, and so an invention of Mr. Korting has been substituted. A steam blast is used to throw air into the water. A very small jet of steam throws in a large mass of air, and that air passing in draws in another quantity of air, and that another, and so on. The water is thus stirred up very thoroughly. The process used in Germany for this purpose is the deposit of the carbonate of lime by means of caustic lime. A deposit of sulphate of lime is accomplished by the use of chloride of barium. The chloride of barium combines with the sulphate of lime and chloride of calcium; the sulphate settles at the bottom of the tank and the chloride of barium remains in the water. So far as the sulphate of lime alone is concerned it seems to have answered a very good purpose, and it has been extensively employed in Europe for the purification of water. There are, however, some waters containing the carbonate of lime, or the sulphate of lime, and other substances that do not seem to injure the boiler or to form any scale. My attention was yesterday called by my friend, Mr. Sedgley, to a sample of the water of the Lake Shore and Michigan Southern Road. The water looks more like whitewash than anything else that I know of. An analysis of a gallon of the water shows that it contains 26.6 grains of solid matter, consisting of:

Sulphate of Lime	3.5	grains.
Bicarbonate of Lime	14.5	"
Bicarbonate of Magnesia	2.0	"
Bicarbonate of Iron	1.5	"
Chloride of Sodium and Potassium	3.8	"
Soluble Silicia	1.0	"
Organic matter and loss	3	"
Making a total of	26.6	"

The water contained nineteen and one-half cubic inches of pure carbonic acid to the gallon. One would think from a glance that this water was as

injurious as any that could be put into a boiler, but Mr. Sedgley says that it does not injure the boiler in the slightest degree or form any scale; the impurities are deposited in the form of a powder which can be readily blown out. I think it would be a very good thing, indeed, if some of the members of the Association would thoroughly test the method suggested by Professor Sewall, and also try the process adopted in Europe of the decomposition of the impurities by the use of lime and chloride of barium. I believe that chloride of barium can be obtained at a very cheap rate. In any experiments of this kind, however, it is necessary to have a correct knowledge of the nature of the water, and definite proportions should be used, otherwise the experiment might prove useless.

Mr. ROBINSON, Great Western Railroad of Canada—Some remarks were made in the report of the Committee with regard to the size and number of tubes in the boiler as affecting incrustation. This is a matter well worthy the consideration of the Convention. I would very much like to hear from those who have given any consideration to the subject, as to the effect of reducing the number and size of the tubes. We know that those who have had occasion to use old locomotive boilers for stationary engines have been disappointed in the results obtained, forgetting that a very much smaller tube is required in a locomotive than in a stationary boiler. Of course, this is a question of the mechanical action in the combustion of the fuel. We have boilers that did contain one hundred and fifty tubes, which allowed only about an inch of space between the outer row of tubes and the boiler shell. I have removed from seven to ten of the tubes from each boiler, and get very much better results than was possible before. I think this fact is worthy of notice in connection with the subject of incrustation. I would like to know whether any other members have tried experiments of that kind. Two and one-half inches is recommended by the Committee as a better size for the tubes than the size now generally in use.* If this be correct, then we must make an important change in our locomotive construction.

Mr. PHILBRICK, Maine Central Railroad—I have had a little experience in reducing the number of tubes, but I did not do it on account of bad water, because our water is good. We had an engine that had a peculiarity of getting out of water; frequently, on attempting to start, the water was found to be so low as to render it unsafe to move without introducing more water in the boiler. I took out fourteen of the one hundred and thirty tubes that were in the boiler and never had any difficulty of that kind afterward.

Mr. SPRAGUÉ, of Pittsburgh—I would like to inquire whether any member has experienced any difficulty in using tubes two inches in diameter and thirteen feet or more in length. Of course, the diameter should be in pro-

* This recommendation occurs indirectly in a letter of one of the Commtttee, but is not recommended in the report.—SECRETARY.

portion to the length, but we ordinarily suppose that two inches diameter and eleven or eleven and a half in length produce good results. If any one has had experience in using a greater length with the same diameter, I would like to know what the result has been.

Mr. HAYES, Illinois Central Railroad—I believe that Professor Sewall is present, and I would like to ask him whether his process of purifying water has been tested in locomotives. I have a bottle in my office, the contents of which were prepared from ingredients sent to me by him, and judging from that sample I should think his preparation would cause the water to foam. On shaking the bottle the upper part of the contents became saponified or full of foam. I would like to hear from the Professor whether its use in a boiler produces foam.

Professor SEWELL—Mr. President, the preparation was tried in a tank containing sixty thousand gallons of water. At first it produced a slight foam, but after a few minutes it disappeared and the result was entirely satisfactory. If I might be allowed I would like to say a few words in addition to answering the question. If the material were put into a boiler in great excess I have no doubt that it would produce more or less foam, but when put into water and decomposition allowed to take place no foam will be produced. If you take a quantity of it and put it in soft water you will be able to blow soap bubbles; but put it into hard water, and let it remain there in proper proportions until the reaction takes place, and it will be as impossible to blow a soap bubble as it would be with any hard water. The operation of decomposition and separation takes place almost immediately. The precipitation will take place in an hour or two, and much sooner if the water contains a large percentage of sulphate of lime. Understand me, that the separation takes place instantly, but the complete precipitation goes on more slowly. Where the sulphate of lime is in excess it will precipitate in half an hour; where the carbonate of lime is in excess it will take a longer time. When added in anything like the proper proportion I am entirely satisfied that it will produce no foam. What Mr. Hayes says is entirely just and true; if you put an excess of it into soft water I have no doubt that it will produce foam.

Mr. HAYES, Illinois Central Railroad—I will state that my experience in testing the small quantity sent me does not agree with the statement of Professor Sewall with regard to the time of its settling. It took about twenty-four hours. During the first twelve hours I could not see any precipitation at all; after that it gradually went down until, in a jar containing about half a gallon of water, there was about half an inch of deposit in the bottom. It was like lake water which becomes very riled after the wind has been blowing several days.

Professor SEWALL—Was the water turbid or clear? If turbid, was it not because of material held in mechanical suspension? I understand that the lake water contains a very small quantity of the lime. I got an analysis

from the city engineer of Chicago this Spring, and from that it appears that the water contains but a trifle of lime. Was it not a fact that the water contains but a trifle of lime. Was it not a fact that the water with which you made the test contained matter held in suspension? You spoke of the water being agitated; perhaps that was the case.

Mr. HAYES, Illinois Central Railroad—Yes; we pump our water right from the lake, and we get a very large deposit in the bottom of the tank. In using Professor Sewall's process we should have to employ three or four times the number of tanks that we now have in order to give it time to settle. This would considerably increase the expense. Our tanks do not contain water enough to last us more than twenty-four hours at a time, and we should have to use two or three times the number if we adopted Professor Sewall's process.

Mr. COLEMAN SELLERS, of Philadelphia—The paper to which I made reference will be handed to the Secretary so that the Publication Committee may use as much of it as they think proper. It gives a very graphic description of the method for the purification of water which is in vogue in Germany. Mention was made in the report of the non deposit of sediment when there was a very rapid motion in the tubes. I would like to know whether that is really the case. My own experience does not correspond with that. We have in our establishment a locomotive boiler in which the water is in the tubes instead of surrounding them, and there is a very rapid current of water passing through those tubes all the time, yet deposits occur very rapidly.

On motion, the discussion was here closed.

The following is the paper of Dr. DeHain, referred to by Mr. Sellers [Secretary]:

Boiler Incrustation and its Remedy.

ABSTRACT OF A TREATISE BY DR. E. DE HAIN, MANUFACTURER OF CHEMICALS, HANOVER, PRUSSIA.

The constituent parts of the feed water for steam boilers which separate as insoluble particles during evaporation, and go to form boiler incrustation, are carbonate of lime and gypsum, or sulphate of lime. The object in view to prevent the boiler incrustation is to remove these parts, or so to transform their chemical composition before the water enters the boiler that they are soluble. In some waters the carbonate of lime, and in others the gypsum, is predominant, and the water has to undergo two separate treatments for the removal of the one, or the other, or both.

REMOVAL OF THE CARBONATE OF LIME.

Carbonate of lime is contained in the water as a soluble double carbonate of lime, which by an addition of an equal quantity of slaked lime (caustic) diluted with water forms two parts of insoluble carbonate of lime, which are then precipitated to the bottom of the tank or vessel in which the mixing operation is performed so that the clear water above is entirely free of the carbonate of lime. If the water be not disintegrated in the manner described before it enters the boiler, the same process will occur in the boiler. One part of the carbonic acid gas escapes with the steam, and the other part combined with the carbonate of lime remains as insoluble boiler incrustation.

REMOVAL OF THE GYPSUM OR SULPHATE OF LIME.

The gypsum or sulphate of lime is an ingredient difficult of solution. Five hundred pounds of water do not solute more than one pound of gypsum. If now water contains but one-half pound of gypsum, in one thousand pounds of water there must be a formation of boiler crust as soon as three-fourths of the water is evaporated. The removal of the gypsum by precipitation in the same manner as the carbonate of lime was removed is not possible, although it has been elsewhere recommended to obtain this result with soda, but the effect is so minute that the result could be but unsatisfactory. To obtain the desired result, the gypsum is transformed into a harmless salt by removing the sulphuric acid gas. By a proportionate addition of chloride of barium the sulphuric acid gas is removed and there remains chloride of calcium soluble in the water. Gypsum and chloride of barium combined form sulphate of barium and chloride of lime. The sulphate of barium settles to the bottom of the tank and the chloride remains soluble in the water. Fifty thousand parts of water solute one hundred parts of gypsum so that, under the supposition that the quantity of the contents of a boiler be fully evaporated once a day, there would be, with water containing an average amount of gypsum within three or four days, a deposit of boiler incrustation amounting to two pounds for every one hundred cubic feet of water evaporated; whereas fifty parts of water dissolve one hundred parts of chloride of calcium, so that a boiler fed with water in which the gypsum has been decomposed could be

worked from five to eight years before the chloride of calcium would become insoluble and form boiler incrustation, so that, also, in this respect, boiler incrustation would become a practical impossibility, as every boiler is blown out at least once a year. The quality of the slaked lime necessary to precipitate the carbonate of lime and the quantity of the chloride of barium necessary to decompose the gypsum depends, of course, on the composition of the water, but the proper proportions are easily ascertained. Although it may appear to be too much trouble to have the necessary tanks fixed for the mixing, and too much expense in the purchase of chemicals, it has been proven by facts and figures that just the opposite is the case. The clearing of the water after proper arrangements have been made is so simple an operation that it does not compare with the necessary work of an occasional chipping off the crust out of the boiler. In point of economy in the consumption of fuel, the effect of boiler incrustation as one of the worst conductors of heat has never been fully appreciated, and any comparative trials made with regard to this point will show a result that almost no reasonable expense would be considered too much to remove the causes of boiler incrustation. During the mixing process the water has to be well agitated, which if done by mechanical means often involves too much expense for a proper mixing apparatus, and if done by hand is too laborious and costly in the expenditure of time. The most effectual apparatus for this purpose, and which is in universal use in Europe, is Korting's Steam Jet Air Compressor which agitates the water by means of an air blast.

THE PRESIDENT—The next business in order is the report of the Committee on Locomotive Tests. The committee consist of Messrs. Forney, Thurston, and Woodcock.

Mr. FORNEY, Railroad Gazette—The Committee are obliged to present themselves without a report; they issued their circulars last Fall, but have not received the information asked for. The replies have been very few, and the data given so extremely meager that the Committee did not feel justified in making any report. Probably one reason why they failed to receive more data was because their circulars were issued very late in the season, and the severe Winter may have prevented members from making the tests asked for. The Committee are responsible for the delay in issuing the circulars, but they are not responsible for the severity of the Winter. Your Committee therefore beg leave to report progress, and ask that they be continued for

another year. They earnestly request members to give all the information they can. They will issue their circular very promptly after the adjournment, and hope that the members of the Association will make such tests as may be suggested, and send such records of tests made in years past as they may have. I know that many members of the Association have such records. Our Treasurer has a perfect mine of such information, and if he will give it to us we will be able to make a very excellent report at our next Convention.

On motion of Mr. Chapman the Committee on "Locomotive Tests" was continued for another year.

THE PRESIDENT—The next business in order is the report of the Committee on Locomotive Construction, consisitng of Messrs. Sedgley, Young, and Fry.

Report of the Committee on Locomotive Construction.

To the American Railway Master Mechanics' Association:

Your Committee, to whom was delegated this subject, issued to the members of the Association the following circular:

CONSTRUCTION OF LOCOMOTIVES.

Your Committee being desirous to present to the Convention, at its next session, such new methods of construction as have been adopted by members during the past, or present, year, earnestly hope (their subject being a general rather than a specific one) that all who have made any positive improvements will present to us, in a manner as clearly and briefly as possible, the nature of such improvements, exact method of construction, and wherein the improvement is positive and valuable.

Your attention is directed to the following questions:

What improvements have you made in the construction of locomotive boilers in reference, particularly, to the saving of fuel?

Have you had any exprerience with the Weston Patent Boiler? If so, with what result as regards economy of fuel, facility of making steam, cost of construction, and maintenance, compared with the ordinary form of boiler?

Have you had any experience with the Jauriet Fire Box, and with what result, as compared with the brick arch?

Please give results of any experience with Buchanan's Water Table.

What, if any, improvements have you made in valves, or machinery for working the same, resulting in a marked saving of fuel or repairs?

What improvements in the construction of trucks under front end of engine, and what advantage gained?

Have you found a perfect spark arrester, or smoke consumer, meeting all requirements? If so, please give detailed description of same, length of time used, and with what results

Have you had any experience with engines of either Fairlie's or Forney's design? Do you consider the rigid wheel base of an average American engine sufficiently destructive to justify attempts to work out either of the designs referred to?

Please describe any improved method of construction of locomotive engines, or any parts of the same, practicable and of real value, the knowledge of which would be of advantage to our fraternity generally.

Your Committee do not care to present new methods which do not possess *positive advantages* over the old, or usual, method.

These circulars, it is presumed, reached each member of the Association; but, much to the regret of your Committee, only five responded, to whom we are very grateful. That the replies have not been general may, perhaps, be attributed to the fact that any experience with the inventions particularly named has been very limited, their use being far from general.

Your Committee, after careful consideration, respectfully submit the following conclusions:

CONSTRUCTION OF BOILERS.

No replies that have been received point to any improvement in the construction of locomotive boilers that have tended to increase the economical consumption of fuel.

One of your Committee has tested a device for increasing the heating surface in the crown sheet, by inserting a number of cast iron hollow globes, screwed by a neck, into the crown sheet. While

no accurate experiments have yet been made to determine the amount of fuel saved by this device, it is evident that some saving is effected, and no difficulty has been experienced from leaky joints, or from mud choking the narrow neck of the globe, although the water used by the engine deposits mud freely in other parts of the boiler. As this device is used extensively in marine boilers, with apparently good results, it would seem worthy of more extended trial.

In reply to the questions concerning the Weston Boiler, no replies have been received as to the cost of construction or maintenance, nor have the results attained, as to the consumption of fuel by engines with this form of boiler, been sufficiently reported to us to enable your Committee to state the comparative merits of the Weston and the ordinary boiler. Trials of this question are still in progress on some important roads, and your Committee hope that some definite conclusions may be reached during the present year.

The replies received from those members of our Association who have tried the Jauriet Fire Box do not enable your Committee to draw any definite comparison between that and the ordinary box with a brick arch. No accurate experiments are reported upon; and as some of those who have tried the Jauriet Box report that they are taking them out, your Committee presume that no practical advantage has appeared from its use sufficient to induce a further trial.

No replies relative to the Buchanan Water Table have been received, or any definite information obtained.

With regard to valves and valve gearing, your Committee have received no replies that show improvements upon the practice already reported to our Association. The use of balanced valves seems to be extending, and experiments are being made on many roads, with different dimensions of lap and lead, but no definite advance is reported in economy of fuel over what has already been laid before the Association.

Your Committee believe that cheapness of construction may be promoted, without incurring any risk of breakage, and with beneficial results as to wear and feasibility of repair, by using cast iron for links.

Your Committee have received no communication describing any form of engine truck not heretofore commonly known.

In the replies received to the question about a satisfactory form

of spark arrester, no information is given that leads your Committee to believe that any positive improvement has been made over the ordinary forms of smoke stacks that have been in use during past years. Several patent stacks are reported on, but no very encouraging results are recorded. One of your Committee, having visited England since our last Convention, was forcibly impressed with the fact that no trouble seems to be experienced there from the throwing of fire. By the courtesy of the Locomotive Superintendent of the London & North-western Railway he was permitted to ride upon an engine, during the night, and to try any means that might occur to him to cause the engine to throw sparks from the smoke stack; but though he worked the engine up the grades with a full throttle, he failed to force any sparks to show themselves.

It is a question worthy the solution, by experiment by the members of our profession, to decide whether this results from the kind of fuel consumed, or if the arrangement of nozzle and stack common in England would produce as satisfactory results in this country. The details practiced in England are sufficiently understood by the members of our Association to render it unnecessary to describe them here.

None of the members replying to the questions of your Committee report any attempts to use steam of a higher pressure than one hundred and forty pounds.

To the question in reference to the results attained by engines of the Fairlie and Forney designs, no replies have been received from any members who have had experience with either of them. Your Committee visited one road upon which a Fairlie Engine, modified by William Mason, has been running for about twelve months. This engine, after having performed very severe service during the whole time it has been running, shows no signs of weakness or defect in any of its arrangements; and it appears to your Committee to be fairly established that, if it be thought desirable to adopt engines of that description, no practicable difficulties will present themselves that may not be easily overcome. It would, however, be premature to pass a decided opinion upon so limited an experience, as difficulties may arise, especially in maintaining the boiler, under the heavy strains thrown upon it, beyond what are due to the steam pressure. If the objects sought to be attained be merely a powerful engine,

your Committee would feel more confidence in recommending an engine of the class known as consolidation. These engines, as now constructed by our best builders, do not have so rigid a wheel base as might at first sight seem apparent. They pass around curves as sharp as are ordinarily found on our railroads without seeming to spread the track or tear themselves to pieces, and we believe that for heavy mountain grades these engines will well bear comparison with any engines in the world.

Appended to this report your Committee present a letter from H. G. Brooks, Esq., President of Brooks Locomotive Works, explanatory of the Roberts Patent Central Exhaust Engine, of general interest to all. Respectfully submitted,

JAMES SEDGLEY,
L. S. YOUNG,
HOWARD FRY,
Committee.

The Roberts Central Exhaust Engine.

OFFICE OF THE BROOKS LOCOMOTIVE WORKS,
DUNKIRK, N. Y., *March* 24, 1875.

JAMES SEDGLEY, Esq., *Chairman Committee, etc.:*

MY DEAR SIR—I am sure I promised, when I saw you last, to give you something on the invention of Colonel E. A. L. Roberts.

I think we have seen enough of the working of the locomotive constructed with the Roberts Central Exhaust Cylinders to be satisfied that there is an advantage in a free, positive exhaust at or near the end of the stroke; the same at all points of cut off. It was to be expected that, in so radical a change, mechanical difficulties of greater or less importance should manifest themselves; but it is a source of no small gratification to me that no difficulties have been presented of such importance as to be insurmountable. There has been really no improvement in the construction of the locomotive for many years, except in the direction of more perfect symmetry, and harmony of detail and proportion. We have still the same difficulty to overcome, growing out of our immense valves, the necessities of our long ports of admission and exhaust—a difficulty, by the way, which no balanced valve yet discovered has obviated. Indeed, my experience on the Erie Railway, with, at one time, one

hundred balanced valves running in my locomotives, comprising valves of nearly every kind in use, was summed up thus: that the added depreciation, and cost thereof, of the details of these balanced valves, more than compensated for any advantage we derived from their use.

The mistake we made in the construction of the central exhaust cylinders was in not taking advantage of a short admission port and a small valve, as we might have done. We are now constructing two cylinders to replace those now upon the "Colonel Roberts," with steam, or admission, ports only eight inches in length. Thus we shall add to the advantage we gain in working the steam expansively nine inches more on each end of the stroke, by the greatly diminished friction of our small valve.

The experiments with this central exhaust have already demonstrated fully to my mind *as a fact* what has long been a theoretical opinion with me, viz.: that the necessities for our extremely long ports lay entirely with the exhaust, and not with the admission. If we leave the same *exhaust* lines we may, in other words, close up the *admission* to one-fourth our present capacity without detriment.

The advantages, therefore, which can be fairly claimed for the Roberts Central Exhaust Cylinder are these:

1. A positive exhaust within three-quarters of an inch of the end of the stroke, entirely independent of the point of cut-off.

2. A perfectly free exhaust, not being confined to the intricacies of the score and the passage under the valve.

3. The ability to use a steam valve for admission, and admission ports of greatly reduced area, without detriment to the efficiency of the engine.

4. The increased power as the result of the postponement of exhaust, and the gain in less compression practically.

5. The ability to attain any speed, as the result of the perfect freedom of exhaust.

6. The economy in fuel growing out of the advantages above enumerated.

Of this latter you can be a better judge, as you have had this engine working under your own supervision. I am satisfied that, when we get the advantage of the cylinders I am now constructing, together with the improved and much lighter piston than we have

heretofore used, we shall be still better pleased with her performance.

That this invention can be safely called an *improvement* I have no manner of doubt. I trust I may be able to finish the new cylinders, and have the engine running, time enough before our Convention in May to be able to collect some data of interest. Trusting this may be the case, I am, my dear sir,

Truly yours,

H. G. BROOKS, *President.*

On motion, the report was accepted.

Mr. SEDGLEY, Lake Shore & Michigan Southern—I move that we defer the discussion on this report until Mr. Brooks is present. He has some drawings which he wishes to submit to the Convention in connection with this subject.

Mr. SETCHEL, Little Miami Railroad—Before the motion is put, I wish to state that we have here some drawings of smoke stacks which Mr. Sedgley received too late to go into his report. They are on the table for the members to examine if they wish.

Mr. Sedgley's motion was then agreed to.

Mr. LAUDER, Northern New Hampshire Railroad—By my motion yesterday the further discussion of the report on the "Construction and Management of Locomotive Boilers" was made the special order for eleven o'clock to-day. I move that subject be now resumed.

Mr. ROBINSON, Great Western of Canada—I would be very glad if Mr. Forney would tell the Convention what we learned on this subject from Professor Thurston at the Stevens' Institute yesterday afternoon. Professor Thurston has been testing some new and old pieces of steel plates taken from boilers, and Mr. Forney has some memoranda furnished by the Professor of the results obtained. I doubt not the information would be very interesting to the Convention.

Mr. FORNEY, Railroad Gazette—Mr. Brooks and Mr. Boon had sent me three specimens of steel, two of which had been used in a locomotive boiler, and the third was a piece of the same sheet which had not been used. They wished me to have Professor Thurston test them in order to find out their relative strength. Professor Thurston has tested them, and given me a memorandum of the result, but I am not quite sure that I understand it; I will, however, give you all the information that I have.

Mr. ROBINSON, Great Western of Canada—I accompanied three gentlemen to Stevens' Institute yesterday afternoon, and this subject was one of the first things that we discussed with Professor Thurston. It was a most curious

fact that he had been trying experiments with this steel, and had arrived at results entirely the opposite of those shown us by our worthy Secretary only a few hours before. The piece of steel shown us by our Secretary was perfectly ductile and pliable before it went into the boiler. Yet after only eleven months of use it became so hard and so nearly like cast steel that it could be broken by a single blow of the hammer. The result obtained by Professor Thurston was exactly the opposite. If there is no objection by Professor Thurston, I would like to have his letter printed with our report as a sequel to this discussion, in order that we may have the conflicting results both stated.

Mr. FORNEY, Railroad Gazette—I do not think that Professor Thurston would have the slightest objection to the printing of that report. He probably expected it to be printed. Mr. Sedgley has handed me a section of steel plate taken from a boiler that cracked. The point of fracture is still visible. It was bent cold into its present shape. I suppose if we want to know whether the steel is good we must bend it, and if it bends without fracture we will have to adopt the old lady's maxim, "it is either good or bad, we don't know which."

Mr. WOODCOCK, Central Railroad of New Jersey—I have brought a piece of steel from the furnace of one of our passenger engines, showing a furrow near the bottom of the ring, and I would like to hear from some of the members whether they have had any experience of that kind. The furrowing has run nearly across the entire surface and has gone nearly through. That engine had run about two hundred thousand miles. I can not tell by whom the steel was furnished; the engine was built at the Taunton Locomotive Works. The furrowing was in the side right near the ring; I do not think there was any mud there as our engines are thoroughly cleaned once in every four weeks.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—In answer to Mr. Woodcock's question I would state that I have frequently observed furrowing in sheets immediately along the top and bottom rings in the fire box, just as in the piece he has shown. I think that it is a very common occurrence, not only with steel but with iron also. In reference to the piece of steel that Mr. Sedgley has produced, it would seem to indicate that the steel, in one direction at least, is perfectly soft and pliable, while in the other it seems to have been brittle. I would like to ask Mr. Sedgley whether the crack shown on the edge of that sample occurred when the engine was being fired up or when it was standing cold. There is a fracture on the edge of it, and if I understand the matter it occurred at some time when the engine was standing still or was cold.

Mr. SEDGLEY, Lake Shore & Michigan Southern Railroad—I will state that the crack probably occurred while the engine was cold and empty—without water. It is our practice, when we can do so, to blow them out and let them remain for six or twelve hours. If we blow them out on Saturday

we let them stand until Sunday evening before filling them. Almost all of our fractures occur when the engines are cold. I have never had one occur when the engine was warm.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—I asked the question because I had a case or two very similar to that. The sheet cracked while the engine was cold, and in order to put on a patch I cut out the piece through the center of which this crack ran—a piece probably twenty inches long, with the crack extending nearly through it. When that piece was taken out it was put upon an anvil and bent cold, without any annealing whatever, just as it was taken out of the fire box. It was bent at an angle of fifty-five degrees; it showed no signs of fracture on the corner, which showed that in that direction at least the steel was pliable; but, for some reason, it seems that in the other direction it was not pliable and would not stand this tensile strain without breaking. It is a new fact to me that a metal may be so pliable as to bend in one direction without breaking, but not in the other. We can all understand how a piece of steel will break when it is hard, but it would seem that it ought not to be brittle in one direction without being so in the other. I would like to know whether any other members of the Convention, who noticed the cracking of sheets, have observed the same thing.

Mr. WOODCOCK, Central Railroad of New Jersey—I have just had in my hand a small piece of steel, taken from one of our boilers, in which the crack is square and white on one side, while the other side, showing the mark of the chisel, is to all appearances of a different nature. I have found that to be the case in a majority of instances. A gentleman has just asked me the question whether there could be any difference in the steel from the way that it was put in when rolled. I can not answer him, and I would like to know whether any one has had experience in that matter. The steel where the cracks occur appears to be of good quality.

Mr. SETCHEL, Little Miami Railroad—I have noticed that those members who have a theory of their own in regard to the cracking of steel will almost invariably present it as a reason in every case that demands a cause. The man who thinks that mud causes the cracking of boilers insists that there must have been mud there, and he cites you to instances where mud was found in boilers that cracked. Another will have a theory that sheets crack only when they are too hard in the first place, and will insist that that was the cause of the cracking. Here is a piece taken from a fire box, which is a little hard; I expected some member to say that that steel was too hard when it was put in, so I brought another piece cut from a plate that was soft when it was put into the fire box, and is just as soft and ductile now; this engine ran seventy-four thousand miles, while the other had run only twenty-five thousand miles. I suppose that that cracked because it was *too soft*. These contradictory cases are just what we want to investigate; we do not want to say that steel cracks because it is too hard and that that is the only reason,

or because there is mud in the boiler and that that is the only reason; for fire boxes do fail without any apparent cause, and where the best care is taken to prevent it, and where the steel is soft as well as where it is hard. Now, if there is a quality in some steel that makes it act differently under the same circumstances, we want to know what that quality is.

Mr. FORNEY, Railroad Gazette—Mr. Wells has propounded an interesting conundrum, whether steel gets brittle in one direction and tough in the other. I suppose that those of you who have the management of locomotives could test that and determine very readily whether steel does get brittle in one direction of the plate and become ductile in another. I am afraid that, in the consideration of this subject of the cracking of steel sheets, we may lose sight of the fact that iron sheets do the same thing. I would like to know what proportion of steel sheets crack and what proportion of iron sheets crack. Is cracking of the sheets more common when steel is used than when iron is used?

Mr. BROOKS, Brooks Locomotive Works—We must not forget in this discussion the difference in service that locomotives are called upon to perform now, as compared with what they formerly performed when iron was used for fire boxes. Neither must we forget the difference in the method of construction of our locomotives. As locomotives are now constructed, the outside connection being almost universally adopted, the boiler becomes really the basic element of the whole structure as I have before remarked. It is positively the frame of the engine, and the cylinders being attached directly to the boiler the forces taken up in the boiler are very much greater than they formerly were when the cylinders were attached directly to the frame, and with no attachment from the cylinder to the boiler except at the extreme end of the frame. This fact should be taken into consideration in determining the relative value of steel and iron; and we must be careful that we do no injustice to steel. My own impression is that if we were to use iron, copper, or any other metal, to the extent that we are now using steel, we should find, with our present methods of construction, that steel would bear the palm against them all. By far the greater number of steel boilers or the fire boxes now in use have given entire satisfaction, and we should not be in haste to condemn the use of steel because there are failures in some cases, but we should seek rather to discover the causes that lead to these failures.

Mr. SELLERS, of Philadelphia—As there has been a good deal said about the cracking of steel I would like to relate a circumstance that occurred a year or so ago. A firm in Philadelphia, largely engaged in the manufacture of chandeliers, had a boiler that exploded, killing a number of persons and nearly destroying the building. They became very timid in regard to the use of steam and looked about them to find a very safe boiler. They rejected all the so-called safety boilers, and finally concluded that they would put in plain cylinder boilers, made with great care and of unusually thick

iron. Messrs. Morris & Co. built the boilers; if I am not mistaken they were made of half-inch plates, which were selected with a great deal of care, and no expense was spared to make a good job. After a certain amount of use one of the boilers cracked about the middle of it. They became very much frightened about it; they had the sheet taken out and very carefully examined, which was found to be very good iron. Another carefully selected sheet was put in the place of it. They had scarcely got that new sheet in before the next boiler cracked in precisely the same manner. They were still more frightened and had it removed and carefully examined, and then replaced with another sheet. Then the third boiler cracked, and by the time they got that mended the first boiler began to crack again. I was then asked to examine them. I found that the boilers were fixed rigidly at both ends and held up by a bar in the middle; there was therefore a continual strain upon the boilers from the way in which they were set. It was simply a case of malpractice in the setting of the boilers, so that the boiler was all the time being bent by the process of heating and cooling, and this bending must of necessity crack them sooner or later. We altered the setting of the boilers, and since then there has been no trouble. I only mention this to show that any metal will yield if it is abused, whether it be steel or iron. These cracks occurred nearest to one of the seams, and where the bending, if any occurred, would be rigidly confined to one point.

Mr. Fry, Philadelphia & Erie Railroad—I think the evidence thus far shows that certain roads in the country have had wonderfully good success in the use of steel, and others seem to be very unfortunate. In collecting information on the subject I think that it would be very important to ascertain the particulars as to the best methods of constructing the boilers, both as to the setting of them and of fastening the boilers to the frames. Several members have referred to the boiler as being a portion of the frame of the engine. I know that there are many engine builders who consider this a radically wrong practice; they consider that the boiler has enough work to do in withstanding the steam pressure, and that we ought as far as possible to eliminate all other causes of strain from the boiler, and to make the engine supported by its frame. I think that it would be of great importance to ascertain the method of construction adopted in the boilers that fail and in the boilers that do not. I hope that, when this question is brought before the next Convention for discussion, this will be made an important point.

Mr. Robinson, Great Western Railroad—If Mr. Wells or Mr. Peddle will not feel annoyed I would like to ask them to tell a little more of what took place yesterday afternoon. I would like to have Mr. Peddle make the same statement to the Convention that he made to us yesterday. I will make a sketch to illustrate. I understood him to say that he tried an experiment with a square piece of steel, covering over a part of it with brick, and exposing the uncovered part to a high degree of heat, Fig-

ure 1 represents the plate before heating and Figure 2 after heating. The plate was just twelve inches square; sections A and B were covered with brick, and the part C was exposed to the heat. Then the fire was allowed to

Fig.1.

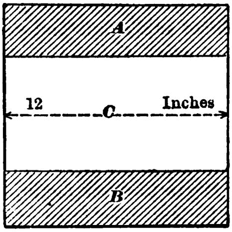
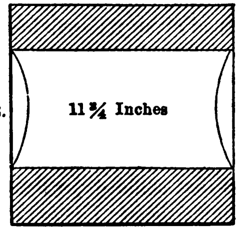


Fig.2.



cool down and then rekindled, thus being made alternately very hot and cold. After repeated experiments the plate took the form of Figure 2. The explanation of that was that the constant heating and cooling of this steel plate caused the plate to gather in upon itself. Professor Thurston thought that the middle part became slightly thicker. This seems to me to indicate another reason why fire-box sheets give way. It is very evident that the inside of the fire box must stand the strain that is caused by this ingathering as well as the longitudinal strain. This strain may be so increased as to cause fracture, and even a blow of the hammer at a critical time may cause the boiler to fracture, the crack starting from any point on that line.* If I am wrong Mr. Wells or Mr. Peddle will please correct me.

Mr. Peddle, Terre Haute & Indianapolis Railroad—I am much obliged to Mr. Robinson for helping me out; he has given about a correct statement of the matter. That sheet was heated seven different times; when heated all over we only found a contraction of about four-thousandths of an inch; but when we heated only a portion of it the whole distance through, the effect took place which Mr. Robinson has shown. I can not give the exact particulars, but we contracted the sheet in a longitudinal direction over one-fourth of an inch; I think that the sheet thickened up somewhat. My idea is that the same action takes place in fire boxes. In the old wood-burning fire boxes I think we had no trouble of that kind as the heat was more diffused, but in coal-burning fire boxes the heat is concentrated up to a level, say from six to sixteen inches above the grate, all around the fire box. The sheet is held in position by stay bolts on the end; it can not give in that direction, and so it must yield in the center. We invariably find that the crack opens more in the center than at the end. I think we have an explanation of this in the fact that the steel gets overheated and then contraction must take place. I have had one or two iron boxes crack. There was an engine made, during the war of poor

* The line between the part exposed to the fire and that covered by the brick.—Secretary.

iron, when good iron was very scarce, and the engine gave out in precisely the same way. I think, however, that a very small percentage of iron boxes give out in proportion to those made of steel. On our road we average five fire boxes per year giving out in that way. The gentleman may suppose that it is owing to the accumulation of mud, but when a man has five fire boxes to repair in the course of a year he is pretty apt to look for the cause of the cracking, and to use every effort to ascertain where the trouble is. We use every care in cleaning out the boilers, and never wash them unless they are thoroughly cooled down. When an engine comes in we let it stand six or twelve hours, then the hose is put on the feed pipe and the water is turned on; at the same time water is blown off at the blow-out cock, so that there is a gradual change in the temperature. After awhile all the water is allowed to run off through the blow-out cock, and then, after waiting a little while, the water is run in again and the boiler filled up, and it is generally when the boiler is being filled that these cracks occur.

Mr. HAYES, Illinois Central Railroad—Can you tell me by what process that steel was manufactured, whether it was Besemer, Crucible, or the Seimen-Martin steel?

Mr. PEDDLE, Terre Haute & Indianapolis Railroad. The Bay State steel gives us the most trouble, and I think that the locomotive works from which we get our locomotives have decided orders to not use that steel any more. I think that I was the first to make complaint of the quality; and after considerable correspondence I got a letter from the firm stating that they had abandoned the use of that steel. I do not state this to injure the manufacturers but to state a fact. We have had some trouble with the Crupp steel, which is excellent for every other purpose; but I think we have had poorer results from the Bay State steel in fire boxes, than from any other that we have tried.

Mr. HILL, Camden & Atlantic Railroad—We never allow the fire to be put out in our locomotives but once a week, and I have never had any very great difficulty with steel fire boxes. I had one engine running for fourteen years with a steel fire box, and I considered that after running the boiler for that length of time it was safer to take it off the road, and as it showed a general weakness all over I condemned it and took it out of service. I would recommend cleaning boilers once a week; I think that would prevent a great deal of trouble in the cracking of the side sheets.

Mr. HAYES, Illinois Central Railroad—I had not intended, Mr. President, to say anything on the subject, for fear I might again be accused of beating around the bush; but, as I have considerable trouble with the cracking of fire boxes and feel quite interested in this subject, I will give some of my views and experience. The most of our furnaces in the West are made of the Crucible steel. In fact, I believe all of our engines with two exceptions, are made of that steel. Those two are made of the Siemen-Martin steel, and cracked in three or four months after they were put into use, the others had

averaged from two to seven years, but some of them cracked after being used for only a few months. Thus far, we seem to have been discussing only the facts, but the cause of this cracking is what we want to get at. What is the cause? That steel does take a chemical change after being used for a certain length of time appears to me self-evident; but what it is that produces that change, or how it is produced, or what means we shall use to prevent it, I don't know, and is what I would like to get some light upon from this Convention, as we have all had more or less trouble from this cause. The experiment of our friend Mr. Peddle reminds me of some experiments that I have made. A few weeks ago I tried an experiment with a sheet nine and three-quarter inches square. I planed up two sheets of exactly the same size, one of which I heated six times to a cherry red and then cooled it off suddenly in water, and I found that over the edges it shrank just one-fiftieth of an inch, while across the metal it retained its original size. I then doubled it down without any fracture whatever; I also took another sheet which had not been subjected to heat, and I found that it bent down readily. I then cut off a piece and put it in a hydraulic press and pulled it in two. I found that the sheet that had not been heated stood sixty-four thousand pounds to the square inch, while that which had been heated ran up to ninety thousand pounds to the square inch, showing that the steel actually increased in strength by being heated and cooled off. I think that all steel shrinks more or less under such treatment. I remember in 1852 of having an engine upon the Baltimore & Ohio Road made for the use of wood fuel. The engine had run for twelve months, and one day while standing in the shop at Wheeling, cold—it had been standing there twelve hours—all at once it went off with a report as loud as a pistol; soon they observed water running from the ash pan. They looked in and found that the sheet had cracked from the top to the bottom; the furnace was perfect in every other respect. If any one can enlighten me as to the cause of such failures, or tell me how to prevent it, I should be glad to have the information.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—I have had some experience in the use of iron boxes for a number of years while we burned wood, and during that time I found as much trouble with the iron sheets cracking as I have since had with the cracking of steel sheets with the use of coal. I think, however, that if we used iron now instead of steel with our coal burners, we would have very much more trouble with its cracking than we had when using wood. We know that in a wood-burning locomotive the fuel is heaped up over the grates almost to the crown sheet, and the fire on top is pretty nearly as hot as at the bottom. The fuel lying immediately against the sheets, heats the top part as much as the bottom, and it prevents any unequal expansion, and for that reason, there is not so much strain brought upon them, and they do not break so readily. If I can have the use of that blackboard for a minute, I would like to call the attention of the Convention to the strains that are probably brought upon the sheets of

fire boxes by the unequal temperature in the sheet. I do this with a view of calling your attention to that particular matter, so that we may more thoroughly investigate that subject, and see if we can arrive at some reason why these sheets break.

Mr. Brooks, Brooks Locomotive Works—Will Mr. Wells allow me to interrupt him? I presume that all the Master Mechanics present would very much like to hear Mr. Peter Cooper, who is now present with us, and I therefore move that we postpone the discussion of this question for a few minutes to give that opportunity. We would all be very glad to have Mr. Cooper address us.

Motion carried.

The President—Gentlemen, I now have the honor of presenting to you Mr. Peter Cooper of this city—the pioneer builder of locomotives in this country. (Applause.)

Mr. Peter Cooper, of New York—Mr. President and gentlemen, this is something entirely unexpected to me. I had no idea of being called upon to speak to you this morning; but since you have called upon me, and as this is a very important question that you now have under consideration, I may be able to call your attention to one or two things which may not have been brought within your observation as they have within mine. You see on that shelf a working model of a steam engine made entirely of glass. That engine has been exhibited before the classes here many times to show the effect of steam in its various operations, and as it was exhibited there was one thing developed which struck me as well worth noticing. The three jars which you see are the boilers where the steam was generated by the burning of gas below. When the engine was running regularly I noticed, by accident, that when the man would raise the safety valve and let the steam blow off beyond the supply of the engine, as soon as the safety valve was raised, and while the engine was running, the water would rise in those boilers some two inches up against the sides. That developed to me one of the dangers in the use of engines which all engineers should be aware of: that whenever they find that the boiler iron has been exposed to the fire by reason of the water getting too low in the boiler, they should close it all right down, and even stop the engine, if they can, instead of letting off steam. By letting off the steam, the additional water rising up in contact with the heated iron creates such a volume of steam that the safety valve can not discharge it sufficiently quick to prevent an explosion. I thought that this fact might not have come to your observation, and as I was unexpectedly called upon to say something, it struck me as one thing that, perhaps, might be of interest to you. They tried the experiment over and over again, with the same result: the water would rise each time some two inches on the side of the boiler. If the boiler had been sufficiently hot, above where the water in ordinary usage is found, then it would have been forced up by reason of the excessive amount of steam generated, and produced an

explosion. This fact may be worth remembering by engineers, that they should be careful, in letting off steam, that the water in the boiler is not allowed to rise above the place it usually fills. A gentleman has just asked me to say something about a very little, insignificant locomotive which I made, I think, in the year 1829. You will see how insignificant it was when I tell you that the cylinder was only three inches in diameter, with a four-inch stroke. It seemed presumption to suppose that such an engine could do any thing on a railroad, and particularly on a road where there was a grade of eighteen feet to the mile, and curves of only two hundred and fifty or three hundred feet radius. I had been drawn into a speculation in Baltimore about that time, with two men who represented that they had very large means. We bought together three thousand acres of land, extending some three miles on the north side of the harbor at Baltimore. After I had been in partnership with them but a very little while, and had paid my portion of the purchase money (we bought the whole tract for one hundred and five thousand dollars), I found that I had paid my part while they had paid nothing, and that I was even then paying their board bills. They proved to be irresponsible men. What to do was the question. I insisted at once that they must either pay up or sell out. I was willing to buy or sell, whichever they chose. They could not buy, and so, after a good deal of bargaining, one man was induced to take ten thousand dollars for his share, and I paid it to him at once. The other, after a while, agreed to go out for a little less. After purchasing their interests I had an elephant on my hands, and the question was what I should do with it. I had to leave my business here while attending to this business in Baltimore. When the Baltimore & Ohio Railroad Company started, it started under very high expectations of fortune to all who were interested in it. I remember that Mr. Patterson told me that they then thought that the road would be so prodigal in its returns that they could afford to make the rails of silver. That was a very extravagant idea, to be sure, but that is what he said. Instead, however, of accomplishing such a result, they found at the end of one year that they had spent their first five per cent. of capital, and had demonstrated the fact that they must change the location of their road, in order to avoid the very short turns which they had at first adopted to save expense. They had learned from their own experience, as well as from the opinions of competent engineers from England, that no road could be successfully run with locomotives on which there were curves of less than three hundred feet radius, and on that road they then had curves of one hundred and fifty to two hundred feet radius. There were a number of short curves of that kind. The Company were plunged into despair, and the principal stockholders determined that they would no longer pay up the assessment on their stock. In the abandonment of that road I saw the defeat of my enterprise. It would have been a terrible defeat to me, for I saw that the growth of the city of Baltimore depended upon the success of that road, and I had purchased that tract with

a view of taking advantage of the rapid growth of the city which was anticipated. I saw that my land was likely to remain for a great while before it could be of use, simply because they could not use the locomotives they then had on the road as they had constructed them. I said to the President and a few of the Directors who were principally interested that, if they would hold on, and not sacrifice their stock for a little while, I would put a small locomotive on which, I thought, could pull a train around those short curves. So I got up a little locomotive. I happened to have an engine in my factory, which I took on to Baltimore, and with some old wheels that I got at the railroad shops, I rigged up a temporary locomotive, and I think it was about as temporary as any you ever saw. When I got ready for an experiment I invited the President and Directors to go out on it. The engine was a new construction altogether. It was a peculiar kind of an engine, which I had gotten up for experiment, and for the purpose of demonstrating a fact which is, perhaps, worth noticing—and I think the day will come when the principle embodied in that engine will be successfully demonstrated as correct. I got the idea that there was a great loss of power in getting a rotary motion through a crank, and I saw the way to get clear of it. I described the method as well as I could to a young engineer of the Sterling Iron Works (this was more than fifty years ago), and he seemed to understand how to do it. I agreed with him to get me up a little engine, and he did so. When it was done he notified me that it was ready for experiment. I went down to Baltimore to try the experiment, and I got permission to attach it to the boiler of an engine three times the size of mine. They were boring a steam cylinder with it, and doing nothing else. One dropped the work and the other took it up, while the safety valve was balanced exactly, and it did not take two minutes to perform the operation. To the astonishment of all who saw it, the *little* engine did the work. I remember the remarks of an English engineer who was there at the time. He looked at it with astonishment, and then said: "If any man had told me that that engine would do that work, I would have told him that he knew nothing about mechanics. I now see that we will yet cross the Ocean in six days." That was fifty years ago, and we have come pretty near his prediction. To give you an idea of how the locomotive looked, I will describe it in a few words. Just imagine a steam cylinder, with a piston rod going entirely through it. Imagine a chain at each end connected with the piston rod, and the chain passing around a wheel at the top, and another wheel at the bottom. With the piston rod this made the chain endless. Then imagine the chain bolted to the top and bottom wheels. Then I put a chain upon the other two wheels, and crossed the chains so that one was loose at the top and the other fast at the bottom. When the engine made its stroke it made alternate motions. There was a catch that caught on the edge of the flange. These catches were borne up by a spring behind them, and as it made this motion one way the catch was perfectly

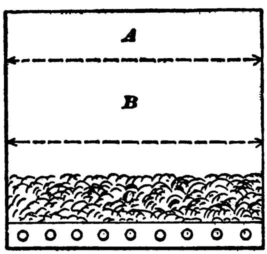
free to slip, and the instant it stopped the other was ready to take it up and carry it on. In this way the rotary motion was kept up about as perfectly as you can imagine. It worked well until the edge of the cogs began to wear, and the hard strain caused it to slip. That discouraged me from making a larger one. I got it all ready to run, and had a temporary track in the shop on which I could run it backward and forward by way of experiment. While I was away for a little while, after I had got it all ready to go on the road, somebody ran it backward and forward on this temporary track, and not understanding the operation, ran it so hard that they broke a piece out of one of the wheels. It was a good deal of trouble to get another; but I did get another, and put it on, got it into the railroad house, and got up steam over night, ready to make a start in the morning. The President and two other gentlemen stepped on the locomotive, and we went out a little way and came back. I felt confident that the next day we would go out with it and have a fair trial. The next day came, but again something had happened to my locomotive. They had been running it backward and forward again, and had broken another piece out of my wheel. So I was delayed until I could get another one made. I had another one made. I was standing by the man watching him as he was finishing it off, and thought we would soon be ready for a start; but, as bad luck would have it, when he was putting the last touches upon it, it slipped out of his hand and broke another piece off. Thought I, the fates are against me. I took that same little cylinder, put it on a cross head with a bottom bar, piston rod, and a couple of little shackle bars, with a crank and a cog wheel, and put the locomotive on the road. When I got all ready I invited the Directors to come and witness the experiment. Just then another little accident happened that I must tell you about. Some good-for-nothing fellow had run off with the copper pipes just for the old copper. I got them fixed, and again invited the Directors to come and witness the start. That time I succeeded in getting off. I got thirty-six persons in one car and hooked on to it. The locomotive carried six men, besides its own fuel and water. You would think that so small a cylinder would not be able to do the work, and the boiler was only about as big as a flour barrel. It was a tubular boiler, with iron gun barrels for the tubes! I feared that I would not be able to get steam enough out of that boiler, and so I attached a blower such as you never saw, I guess. I screwed a crooked joint on the top of the smoke stack to hold my blower, and carried a belt down over a wheel on the shaft, and so I got up speed enough to run it. I found that I had sufficient power to draw the shavings right through the boiler. I put my blower on and got up the steam. I set my safety valve at the amount of steam I wished to carry, but I found that the steam blew off too fast. The safety valves would discharge the steam so rapidly that I thought all of the water would go out of the boiler. I could not conveniently alter the safety valves, and I knew that the boiler was strong, so I put my hand on them and held them down.

Insignificant as that little engine was, we made the trip of thirteen miles in an hour and twelve minutes, making all the short turns, and demonstrated the fact that a locomotive could be made which could go around those short curves, the thing that I set out to do. We had it down hill in coming back, and made the run in forty-seven minutes. Some four years ago I met Mr. Latrobe, then the counsel for that road, at Newport, and he asked me if I had received a pamphlet from him. I told him that I believed not. Said he: "Then I will send you one. I was one of your passengers on that trip to Ellicott's Mills, and took particular note of every thing that transpired, and of every mile we traveled, and of the minutes and seconds we were in doing it." He said that he had been delivering an address before an assembly in Baltimore, and had taken the opportunity to describe this trial trip. He sent me the address, and it gave me information which I was not aware existed. I believe that that little engine, simple as it was, had a good deal to do in stimulating the people to go on with that railroad, which is now such an honor to the country through which it passes, and in which the whole country may well feel a just pride. But I will not occupy any more of your time. I had no expectation of being called upon to say any thing, but willingly give you the little information I have.

On motion of Mr. Garfield a vote of thanks was tendered Mr. Cooper for his kindness in addressing the Convention, and on motion of Mr. Brooks a recess of ten minutes was taken in order that the members might be personally presented to Mr. Cooper.

After recess, the President requested Mr. Wells to proceed with his explanation of the drawing on the board.

Mr. Wells, Jeffersonville, Madison & Indianapolis Railroad—I want to call the attention of the members of the Convention to the unequal strain in sheets caused by unequal temperature. The diagram is intended to represent the side sheets of a fire box. It is very evident that the part of a



sheet which is directly in contact with the coals will become much hotter than the portion of the sheet above. The temperature at C is nearly double what it is in the balance of the sheet, and the expansion of the metal must necessarily be neariy doubled. Now, if the distance on that line C be less than the expansion, or if the expansion exceeds the elastic limit of the

metal, then it must thicken up. It is impossible to stretch the upper part of the sheet and stretch the bottom part of it with the small amount of metal that is so highly heated, because the portion of the heated metal is small in comparison with that which is comparatively cold; it seems to me, therefore, that the metal at C, as it is not able to expand the balance of the metal, will thicken up just as when you bend a piece of iron beyond the elastic limit, it will thicken on the inside. As soon as the sheet is heated there is no danger of any rupture, but when the sheet cools down there is danger; and it is important for us to know what is the condition of the sheet when it is perfectly cold. If the metal at C thickens up and accommodates to the space it occupies when hot, then when the whole sheet cools down the metal at C must necessarily be too short. It must then stretch out again. If the metal is not sufficiently pliable to permit it to draw out and fill the space, then it will break or crack. As long as the metal is flat there is no danger of cracking, but every time the boiler is fired up and run with a heavy fire the metal at C must thicken up or shove together to accommodate itself to the circumstances; and when it is cooled down again it must elongate. The question is, what effect does that contraction and expansion have upon the metal? When this thickening up and drawing out is going on day after day, is it not reasonable to suppose that it will in some way affect the metal itself the same as an undue strain affects an axle, or as an undue vibration will affect a piece of iron? There is an unequal strain brought upon the metal from the fact that the metal all around the fire box is expanded, and it does not expand alike in all directions. This is a matter to which I wish to call the attention of the Convention. I do not say that that is really the cause of the sheets cracking, but it looks reasonable to me to suppose that that force continued for some length of time will eventually destroy the sheet in that particular. The more highly heated this part of the sheet C the greater the expansion, and the greater this thickening up will be, and when it cools down again the greater will be the strain brought upon it to bring it again to its original position. Where bad water is used, and a scale accumulates in the inside of the sheet, then the part along the fire box is very much hotter than it would be if the sheet were entirely free from scale. If that be the case then this thickening up and elongating will occur to a greater extent than it will when the sheet is clean. That fact seems to me to account for the difficulties which result from the use of very bad water. When wood is used as fuel we do not see precisely the same results as when coal is used. In using wood the fuel often extends up to the crown sheet and lies immediately along side of the side sheets. The sheet at the top is perhaps not quite as hot as the sheet at the bottom, but it is very nearly so, and therefore the expansion is more nearly equal. But with coal the fuel extends but a very short distance up the side sheet, and the part opposite the coal is very much hotter than it is above; therefore, the expansion is unequal. As far as my observation goes when sheets crack, the crack invariably

occurs about the center of the sheet, commencing, perhaps, at the top of the grates and extending upward. The metal on the line C thickens up, and when it is cold may, perhaps, be on sufficient tensile strain to start a crack. If a little crack starts next to the stay bolt, then the strain that that point originally had is thrown immediately above, and the consequence is that there is a tensile strain on that point tending to pull the metal apart; and when it starts, no matter how little, the probability is that the crack will run up and down, just as we have heard described. I mention this matter to the Convention for their consideration and investigation. We can all think it over, and, perhaps, during the next year can gain some further light on this subject.

Mr. SELLERS, of Philadelphia—I would like to ask Mr. Wells why the same effect does not occur in the fire door or the flue sheet. Are they not subjected to the same heat?

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—I will explain why I think it does not. If the sheet were very narrow at C the difference in the expansion of that piece above and the piece below would be less. The sheet being narrow it would more easily accommodate itself than a very wide sheet. I think it will be found that where the sheets are wider the greater is the danger of cracks in the middle of them. If a sheet is very shallow in this direction—length of box—then the danger from rupture through *here* would be decreased, because there is then only a small portion that is at a lower temperature, and that expands the surrounding parts, and thus the different parts will accommodate themselves to each other. Some of the gentlemen have spoken of a fire box constructed with a seam running through at B, and they stated that they had no trouble with the sheets cracking. That was, perhaps, due to that seam. The seam will give more readily than the solid sheet. If the cause of the sheets breaking at B is on account of the metal shoving up and then thickening until it finally crystalizes or hardens, then it would seem that a remedy could be had by putting two or more little curves in the middle of the sheet. It seems to me that that would give it an opportunity to adapt itself to a difference in the temperature. The only question then would be whether there would be any liability to rupture at those points on account of the bending of the metal. It seems to me that if those corrugations were to be put in they should be put in between the bolts, so as not to confine them, but to allow them to spring in and out.

Mr. FRY, Philadelphia & Erie Railroad—I would like to inquire from some of the members if it is a fact that the side sheets are the only ones that give any trouble. I think one of our members asked if the same effect would not be produced upon the flue or end sheets. I do not know but that I ought to apologize for rising so often and asking for information without giving any; but I believe that at all entertainments it is as necessary to have good listeners as it is to have good story-tellers, and owing to my having

changed location during the past year I have no new facts of my own to bring forward, but I can assure members that I am a most excellent listener. I am paying great attention and taking great interest in all that is said. A road that is probably better represented than any other in this Convention (there being no less than six of its officers present, the most of whom have had great experience in the use of steel), has not yet been heard from upon this subject, and I would like to call upon the officers of that road to give us the information that we are after. I dare say that they have not been willing to proffer the information owing to the natural diffidence and innate modesty that has always characterized the officers of the Erie Railway; but I think, as that road is so largely represented, we ought to have some information from its officers. I have learned several interesting facts from members of that railway. I have been told that they have a steel fire box differing from the usual mode of construction, which has been running for thirteen years and shows no signs of deterioration. As it is our object to collect all the information possible, I beg leave to call upon some gentlemen of that road for particulars.

Mr. Clark, Lehigh Valley Railroad—Mr. President, as the gentlemen referred to do not appear ready to respond, I wish to ask Mr. Wells how he knows that the sheet is hotter at the lower part than at any other side of the fire box. My experience is that heat goes up and it is distributed by the water and that one part is as hot as another.

Mr. Wells, Jeffersonville, Madison & Indianapolis Railroad—I have not tested it with any instrument, but I only infer so from the fact that it seems natural that the part of the sheets nearest to where the heat is generated must, as a matter of course, be hotter than parts that are further away. The sheet above, of course, has water inside of it the same as it has below. If steam is made to form very rapidly at C, it would be very natural to suppose that a certain portion of the surface of that sheet is in contact with the steam that is formed, and if it is in contact with the little globules of steam, then it must obtain more heat than the parts above and farther away. It seems reasonable to suppose so, and the indications of the bolts and the sheet itself seem to show to me that there is a great deal more heat opposite the fire than there is above.

Mr. Robinson, Great Western of Canada—I think Mr. Wells stated that the fire was much hotter down at the bottom than it was higher up, and that this difference in heat was in consequence of the fact that in wood-burning engines the fire was deeper than the fire in the coal-burning engines. I take Mr. Wells' remarks to mean that a coal fire is hotter below and cooler above as compared with a wood fire. That brings me to ask him a question. We have about twenty locomotives with solid rings around the door. Those engines give no trouble while we burn wood in them, but as soon as we alter one so as to burn coal in the engine a series of fractures dart around the

solid ring on the inside of the steel fire box; and we are forced to avoid putting any coal into them. With those engines that are built without the solid ring we have no trouble. Can Mr. Wells, or any one, explain the cause of this trouble which would seem to indicate that the heat was greater on the upper part of the sheets with coal fuel than with wood?

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—There is one reason why the ring around the fire door will crack more readily when coal is used than when wood is used, and that is because there is more hydrogen in the coal than in the wood; and this is especially true when soft coal is used. There is no door in a locomotive but what leaks more or less, and thus allows air to pass in. This heated hydrogen comes to the door and meets the oxygen of the air, which gets in around the door and burns on the instant, just the same as a gas-jet will burn. Perhaps on that account there may be more heat at the door than there is with the wood fire. At the same time it is altogether probable that the whole inside surface of the fire box is at a higher temperature when coal is used than it ordinarily is with wood. There may be some other reasons for the ring leaking. I have had occasion to replace those rings even with wood-burning engines. A solid ring will last, perhaps, for a year or two without giving any trouble, and it may last three or four years, and even longer. But even then with wood-burning engines I have frequently observed that they will leak.

Mr. BROOKS, Brooks Locomotive Works—I shall have to offer the same apology that Mr. Fry has made for consuming so much of your time. It seems to me that there is a misunderstanding with regard to the exercise of the forces that are brought to bear inside of the sheets of the fire box, as to the quantity and quality of those forces. It is not a heavy strain suddenly brought to bear that does this work, but it is the minute strains continuous and consecutive. The last discussion illustrated something of that character. Mr. Robinson says that in his solid rings he has trouble when using coal for fuel, but that in his open flange sheets there is none. Now, I take it that that difference is the same as there is between the square shouldered axle and one with a fillet. There is no more strength by putting the fillet there, but the difference is this: that in the one case you have an abrupt line termination of your vibrating force, and in the other it is diffused. You see this idea illustrated by the man in the circus who throws up a cannon ball and receives it on the back of his neck. He elongates that force through a quantity of time. In the curved form of the door sheet you bring in that principle. You elongate the period of the reception of one of these minute forces through this curve, while in the other case you terminate the force exactly at the rivets, and, therefore, there is where your strain is. If you will observe you will find that in almost every case the effects described are due to this cause, that in certain circumstances there has been a termination of these forces at a fixed point, and this termination has finally resulted in fracture.

Mr. SELLERS, of Philadelphia—Let me ask Mr. Brooks how it is that the crack occurs in this square shoulder when one kind of fuel is used and does not when a different fuel is used.

Mr. BROOKS, Brooks Locomotive Works—The force exerted is the same in quantity but not the same in quality. In the one case it might take a thousand years to effect a certain result, while in the other it may be effected in a short time. The difference in result is not due to the quantity of the forces brought to bear so much as to their quality, and in its effects there is a vast difference between a coal fire and a wood fire.

Mr. SELLERS, of Philadelphia—Excuse me for interrupting you again, but the President of Stevens' Institute is present, and I would like to have him say a few words about the molecular changes that take place in iron. I intended to make some remarks myself upon this subject, but he is much better fitted for it than I am. If wrought iron is struck ever so light a blow it changes its condition, and he can relate an experiment which he made to illustrate this principle. He can show you how a piece of iron when struck even with the hand changes absolutely its molecular conditions.

Professor MORTEN, of Hoboken—Mr. President, Mr. Sellers has asked me to state this fact, and I will mention it in as brief a form as possible. You are, of course, all familiar with the character of magnetism. It was shown long ago that when a bar of iron becomes magnetic its physical structure is changed—it elongates. You may take a bar of iron and fix it so that an accurate measurement of its length is accomplished, and then magnetize it and it will grow longer; it will move the index of the instrument and show that it has grown longer through the molecular changes of its composition. That being understood, we will next notice the feebleness of the force that is needed to produce such a definite change. We all know that the earth has magnetism. We are all familiar with the mystery of the attraction of the needle to the pole, which is taken as a type of constancy. But the constancy of the needle to the pole is a constancy that is very easily overcome. It is true to the pole only so long as there is nothing to disturb it. The feeble force which acts upon the needle makes it turn toward the north pole. If we hold a bar of iron in such a direction that the magnetism of the earth acts upon it favorably, it will become for the time being magnetic. If we bring a needle near it, it will attract the needle. It becomes magnetic by reason of the same influence which we see making the needle point toward the north. That faint force has affected the molecular structure and made the iron magnetic. If the bar of iron is then placed in an unfavorable position it loses all its magnetism. But, if while in this favorable position we strike the bar with the hand and then test it with the needle, we find that it has retained its magnetism. That feeble force aided by the shock given to the bar, has effected a change in the molecular particles of the iron which is apparent. I mention the feebleness of the force to show how little it takes to affect the molecular structure of a bar of iron. The experiment

that I have mentioned is not one of mine but that of one of my colleagues, who has given a great deal of attention to the subject. Mr. Sellers called upon me to describe it, and I have given you the description as an illustration of how little it takes to change the structure of a bar of iron, provided we give it a jar or shock sufficient to set it in vibration.

Mr. SETCHEL, Little Miami Railroad—There is one idea connected with the explanation that Mr. Wells has given, that, to any one not better posted than myself, would seem a little strange. Mr. Wells asserted that the sheet was much hotter below than above, but there has been no test made to ascertain that fact. There is, however, a little test that has been known to us for a long time that seems to me to contradict that assertion. You can take a boiling tea kettle from the hottest coal fire you can make and put your hand on the bottom without being burnt.

Mr. SELLERS, of Philadelphia—Can you do that?

Mr. SETCHEL, Little Miami Railroad—Yes sir; I have tried it, and that being the case, how can that portion of the sheet in contact with the fire be hotter than it is above?

Mr. SELLERS, of Philadelphia—Is not that the fact only when wood is burned?

Mr. SETCHEL, Little Miami Railroad—No, sir; I stated a coal fire. Any of you can do it if you desire to try it.

Mr. SELLERS, of Philadelphia—How long had it been on the fire?

Mr. SETCHEL, Little Miami Railroad—It had been boiling long enough for the steam to issue from the spout.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—I only explained that the point where the difficulty occurs is not at the bottom of the boiler, but is, perhaps, a foot above. As Mr. Setchel knows very well the grates are set up generally eight or nine inches above the bottom rings, and the overheating occurs probably at the top of the fire or a little above that. There is where we usually find the most difficulty; there is plenty of room for the cold water to come to that point.

Professor MORTON, of Hoboken—I think it may be interesting to draw a little attention to the very remarkable experiment which has been mentioned, and which is one well known for a long time. It admits of a rational explanation. Of course, if the hand were in contact with the iron, which was itself in contact with the boiling water, the hand would be scalded or burned. The hand can not stand the temperature of boiling water; but if a tea kettle has been used over a bituminous coal fire it can not be used long without getting a thick coating of lampblack or fine carbon upon it, which is a poor conductor of heat, and therefore, when the hand is placed on the tea kettle, it is saved from being burned, not from lack of temperature in the tea kettle, but because the non-conducting carbon is between the hand and the kettle. Of course, if the carbon were removed, the hand would be burned or scalded.

Mr. Forney, Railroad Gazette—A gentleman near me says that you can bear your hand on the kettle as long as the water is boiling, but that as soon as the water stops boiling, be careful. It is possible that the heat becomes latent, and that the steam carries it away from the metal in the process of boiling.

Mr. Setchel, Little Miami Railroad—The idea advanced by Mr. Wells was that the plate was hotter because it came in contact with the fire, and was therefore permanently contracted by being held from expanding when in this condition. My point is that, whether it is protected by carbon, as Professor Morton states, or whether from some other cause, the plate is not so hot but that you can put your hand on it without being burned. It seems to me that that would go to show that the temperature of the sheets at the bottom of the fire box is not so much greater as has been supposed by Mr. Wells.

Mr. Hudson, Rogers Locomotive Works—It is a fact, with regard to the tea kettle, that if you hold your hand in contact with it until the water ceases to boil you will be apt to be burned; I have tried the experiment and know that to be so. In regard to the changes that take place in boiler plates I have no doubt at all but what Mr. Wells' explanation of the upsetting of the particles of the sheet is the true explanation. Whether it arises from incomplete or insufficient circulation, or from whatever cause the overheating takes place, I have no doubt that the overheating is the primary cause of the ultimate breaking of the sheet. But it has been mentioned that time has something to do with it. Time is an element, and a very important one, in determining how soon this cracking will take place. I believe that it was well established years ago by the Franklin Institute that, while good iron would stand tensile strain of sixty thousand pounds to the square inch on a direct test, they found that fifteen thousand pounds with a continuous strain would pull it apart. This shows the effect of time; it requires time to develop these changes. The quality of the steel and the size of the sheets has a great deal to do with the time when the breakage will take place. If you have a metal which is capable of withstanding without injury all the expansion which takes place, owing to this undue heating, that is just the material you want. In the absence of that material what shall we do with the existing material to make it more serviceable? We must put it in such shape, either by corrugation or otherwise, or by better means of circulation of the water, so as to carry off this heat and prevent any undue heating, or we must get a material that will stand the heat. The reason why the flue, back, and the small sheets do not give way as quickly as the side sheets is, I apprehend, simply in consequence of their size, not that the circumstances are changed otherwise. I must say that corrugating the sheets promises to be the most practicable method for preventing the difficulties now experienced. As to the relative merits of iron and steel I know of iron fire boxes that have been burning coal,

and that have been in use for five or six years, that are apparently as good now as when they were put in. I know of a steel furnace under the same circumstances, and I know of others, that have not stood for even a few months. I am not able to say what it is in the material that causes the one to break and the other not to break, but there seems to be something in the quality of the metal itself which, in the one case, renders it capable of taking up and giving out all this expansion and contraction without injury, and in the other case produces fracture. It is an important inquiry to know what the difference in the quality of that material is, and to what it is owing, so that we may with certainty manufacture sheets of the quality that we know from experience will answer the purpose designed. One of the gentlemen asked how we know that one part of the sheet is hotter than another part. How is it that a coal fire causes the sheet around the door to leak when a wood fire does not? Is it not due to the difference in temperature? I will say that, of my own experience with solid rings in burning wood, they frequently leak and crack; but when you use a sheet in place of the solid ring you prevent that in a great measure, because the heat is then carried away by the better circulation of the water—there is not so much material as with the ring to become unduly heated. That, I think, is the explanation.

Mr. MILES, of Philadelphia—I wish to make a proposition, and that is that we instruct the Committee to put in their circulars to Master Mechanics certain questions which will call out further data on this subject. Let them, for instance, put a question asking that each Master Mechanic furnish a reply stating how many sheets cracked during the year.

THE PRESIDENT—Let me say before you proceed any further, that this subject has not been presented for consideration during the next year, and that if it is desired to have it considered at the next Convention it will be necessary to lay it before the Committee on Subjects.

Mr. SETCHEL, Little Miami Railroad—Such questions were framed last year.

Mr. MILES, of Philadelphia—Mr. President, would it be out of place to make a suggestion of what might be done?

THE PRESIDENT—Not at all.

Mr. MILES, of Philadelphia—I was going on to say that in Europe they are not using steel fire boxes in anything like the number that they are using here, and that they are looking to us to see what our experience will be in using steel plates for fire boxes, and it behooves us to find out all the facts connected with the subject, and to elicit all the data that any road can give, not only this year but next, and from year to year. I want to suggest further, that it would be a very useful thing if the committees would so frame their questions as to leave blanks, so that the party receiving a circular would find a blank space opposite each question in which he could write the answer to that question in the fewest possible words; and then a member

would not be obliged to scratch his head and think half an hour before he could start his answer, and then to write a long article which might just as well be dispensed with by the use of blank forms. I think by so doing we would elicit the detailed information we need.

Mr. SETCHEL, Little Miami Railroad—It has been suggested, and I think very properly, that we recommend to the members corrugation as a remedy for the cracking of sheets.

Mr. SELLERS, of Philadelphia—You had better put that as a motion, in order to get the sense of the Convention.

Mr. SETCHEL, Little Miami Railroad—Then I move that we recommend the members of this Association to try corrugation as a remedy for the cracking of steel sheets.

Mr. SELLERS, of Philadelphia—In suggesting that motion to Mr. Setchel, my object was to get the sense of the meeting, so that if members vote it down, it shows that they do not approve of corrugation. If they vote in favor of it, it shows that they think corrugating will serve as a remedy to prevent the cracking.

Mr. GRAHAM, Lackawanna & Bloomsburg Railroad—I would like to say a few words about corrugating sheets, as I have had considerable experience in it. A great many think it is an additional expense, but it is a simple matter, and I do not think it would cost five dollars to corrugate all the sheets of a furnace. A sheet can be corrugated in an hour. It is done in the rolls. It is placed under the rolls, and by screwing down the top roll a sufficient distance, then slackening it up and reducing it alternately, you can pass the sheet through. After they are corrugated in that way across the sheet, we simply straighten the edges while it is heated red hot. The center line of corrugation is about three-eighths of an inch—there is a little more thinness of the iron on each side of the center line. We keep the edge of the iron in the center line of corrugation, and bring the row of stay bolts on top. I have used corrugation for six years with good results, and there is very little additional expense or trouble attending it.

Mr. CHAPMAN, Cleveland & Pittsburgh Railroad—In adopting a resolution of this kind, it may be better to go a little slow. I do not know that it is right to take the sense of the meeting in this way. I think that it is better to leave it for each member to act as he sees fit. I understand that there are several parties claiming patents on corrugated sheets. I do not wish to convey any inference that Mr. Setchel is interested in any of them, but we might, perhaps, infer it from the motion.

Mr. GRAHAM, Lackawanna & Bloomsburg Railroad—I am not aware of any patent on it, although several parties have applied for patents. One party got it from me, and applied for a patent afterward, but was not successful. I had a model made, and applied for a patent also, but was told that it was not patentable.

Mr. CHAPMAN, Cleveland & Pittsburgh Railroad—I think that a gentle-

man in Chicago, connected with the North-western Road, claims a patent on it.

Mr. GRAHAM, Lackawanna & Bloomsburg Railroad—He applied for a patent but the application was rejected.

Mr. SELLERS, of Philadelphia—It is a very old device, and not patentable.

Mr. SETCHEL, Little Miami Railroad—Mr. President, I will agree to be fair in this matter, and if I should be so lucky as to realize anything from the adoption of my motion, that as an inducement for him to vote for it, I will divide with the Vice-President.

Mr. BROOKS, Brooks Locomotive Works—I second the motion to get the full sense of the meeting upon this subject; and I would suggest that every member here be requested to vote upon it one way or the other.

Mr. FRY, Philadelphia & Erie Railroad—Let me fully understand the question. If we except Mr. Setchel's proposition, does it commit the Association to the approval of corrugating sheets? or does it simply request that an experiment be made in that way?

Mr. SELLERS, of Philadelphia—I do not desire to commit the Association in the slightest degree, but to get the sense of the members present as to this proposition. Will a change of form be likely to obviate this trouble, whether that change be corrugating or some other change from a plain flat sheet? It does not commit the Association to corrugating in any way, but it is simply a vote of recommendation that it be tried. Mr. Setchel has well worded the motion without committing the Association to any thing; it merely says that the Association recommend that the attention of members be directed to corrugation, or to some other change of form, as a remedy for the cracking. I do not think that any member ought to vote for it with the idea that it commits the Association to adopt that form. It merely gives the sense of the members present on this subject.

Mr. CHAPMAN, Cleveland & Pittsburgh Railroad—I understand the motion to be a recommendation that the members of this Association try it.

Mr. SETCHEL, Little Miami Railroad—That is the motion, that the members be recommended to try corrugation.

Mr. CHAPMAN, Cleveland & Pittsburgh Railroad—It seems to me that that would commit the members. If I vote in favor of it I would feel under obligations to try it.

Mr. FORNEY, Railroad Gazette—I should like to amend the motion by adding the words "if they choose."

Mr. SETCHEL, Little Miami Railroad—I think that is implied in the recommendation.

Mr. FLYNN, Western & Atlantic Railroad—I differ with Mr. Sellers in regard to the motion; as I understand it, the motion made by our Secretary is, that the Association recommend corrugated sheets for side sheets.

Mr. SETCHEL, Little Miami Railroad—No, sir; that is not the motion, but

that we recommend the members to try corrugating as a remedy to prevent the cracking of side sheets in locomotive furnaces.

Mr. FLYNN, Western & Atlantic Railroad—Then, as I now understand it, I will vote for it; but as I understood it at first, I would have voted no. I understood it at first as committing the Association to corrugating. We have had the experience of only one who has tried this remedy. I am frank to admit that my prejudice goes for it, and I think that it would meet, to a great extent, many of the difficulties that many roads labor under from the cracking of the side sheets of the fire boxes.

Mr. PHILBRICK, Maine Central Railroad—I understand that the design of this corrugation is to counteract the expansion and contraction. Now, we understand that there is contraction downward as well as lengthwise. The stay bolts are often broken in consequence of the contraction downward. Will you corrugate these sheets both ways so as to meet that difficulty?

Mr. SETCHEL, Little Miami Railroad—I supposed that that matter was understood. The Committe reported that there were no cases given them of the cracking of sheets longitudinally. It was all up and down the fire box, except, occasionally, in a zigzag direction across the fire box. My idea in the motion was to carry out the same thing that Mr. Wells has suggested. I think that we ought to take some steps in regard to this matter, and I do not know of any better way than to recommend to our members something that seems feasible. We know that there is an undue strain there, and if we can mitigate or prevent the evil by corrugating the sheets, it seems to me that the result is worth the effort. My idea is to have the Association recommend the trial. I thought my motion was sufficiently distinct to show that we only recommend the members of the Association to *try* corrugating as a remedy to prevent the cracking of steel side sheets.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—I think that we can not vote very intelligently upon this question, as few of us have tried corrugated sheets, and it therefore seems scarcely worth while to pass a resolution of this kind. It seems to me that we should let this matter pass, and let the members use their pleasure about it. If any member has an opportunity to try corrugated sheets, and believes that there is anything in it, and that it will obviate the difficulties complained of, he will try it without a resolution. It is not necessary to bind the Convention by a resolution recommending members to try it. The members will try it without a resolution if they think there is anything in it. They are all anxious to get better results generally than we have had in the use of steel.

Mr. FRY, Philadelphia & Erie Railroad—I would like to amend the resolution by adding this: "That looking at the great importance of the introduction of steel in locomotive boilers, the Association requests the members to make such alterations in the form of fire boxes as may seem to them, from the facts laid before them during this Convention, most likely to obviate the

cracking of steel plates, and other defects which have shown themselves." This would leave it optional to the members to do what they see fit.

Mr. CHAPMAN, Cleveland & Pittsburgh Railroad—Would it not be the natural course for each member to do that without a resolution.

Mr. FRY, Philadelphia & Erie Railroad—It might be so; but I think that, unfortunately, many of us are so situated, or are in such a position that we need something to help us, something to give us weight in laying our opinions before the officers of the roads we represent. I say this with considerable diffidence. I hope I am not disparaging the position we hold in the railroad world, but I can not help feeling that we sometimes need something to strengthen us in proposing any alteration in the important parts of an engine. I think it would, perhaps, add to the weight of this institution if it were customary to bring forward the opinions expressed in the Convention to the attention of the railroad officers, and if we are careful to not recommend any thing that is bad or that is untried, it is possible that the opinion of this body may come to have due weight with railroad officers.

Mr. LAUDER, Northern New Hampshire Railroad—It seems to me that this amendment had better be put in the form of a substitute for the resolution.

Mr. ROBINSON, Great Western of Canada—I think, according to the feeling expressed by members, that at present it would be better for the Association to recommend to its members to devote their attention to changes in the shape of boilers, as a remedy for the cracking of sheets. I think a recommendation to direct the attention to that, as a remedy, would be more acceptable.

Mr. FRY, Philadelphia & Erie Railroad—I accept that amendment as a substitute for mine, in order to get the matter before the Convention, or I will accept any suggestion that Mr. Robinson may make.

Mr. ROBINSON, Great Western of Canada—I would then suggest this resolution: That this Association recommend to its members that they shall turn their attention during the next twelve months to the advantage to be gained by an alteration in the shape of the plates as a remedy to overcome the difficulties experienced in the use of steel plates.

Mr. SETCHEL, Little Miami Railroad—I have heard that there is a difference in ginger, but I never could distinguish it. I will accept that amendment although I can not see that it is any different from the original motion.

By consent Mr. Setchel withdrew his resolution, and Mr. Robinson's was substituted therefor and adopted.

On motion, the discussion on this subject was then closed.

Tests of Boiler Plate,

Made at the Mechanical Laboratory of the Stevens' Institute of Technology, Hoboken, New Jersey, May 11, 1875, *by Professor R. H. Thurston;*

Laboratory number..	Limit of elasticity..	Ultimate strength per square inch of original section..........	Ultimate strength per square inch of final section..............	Maximum elongation.	Equivalent resilience.	Modulus of elasticity..
338	40,180	56,024	99,345	0.773	28,871	20,090,000
389	38,562	53,205	.109,532	1.059	37,562	19,286,000
390	30,928	59,983	77,371	0.289	11,557	15,464,000

The value of their resilience indicates power of resisting shock. The *used* metal is much the best.

REMARKS ON TESTS.

Boiler plate previous to and after use: Nos. 388 and 389 were taken from a plate which had been used for some time in a steam boiler. It had no appearance of having been injured.

No. 390 was a piece of plate which had never been in use and which was said to have been made for the same purpose and to be of the same grade.

The latter statement being accurate, the effect of use is evidently to *anneal* the metal, making it softer and very much more ductile, as shown by the maximum elongation deduced by comparison of original and fractured sections.

R. H. THURSTON.

THE PRESIDENT—Before we commence another report, I want to call the attention of the Convention to the fact that we have a great deal of business to do, and I think we shall require more sessions than usual. We generally meet from nine to two o'clock each day; but as the people here have seen fit to take charge of our ladies for the balance of the day, I would recommend that we have a session here this afternoon, say from three to six o'clock, and that we adjourn at half-past one. By so doing we may obviate the necessity of a night session.

Mr. CLARK, Lehigh Valley Railroad—I move that we adjourn at half-past one to-day, and meet in session at three o'clock.

Motion agreed to.

THE PRESIDENT—I hope that every member will be present at the afternoon session, with the exception of the Committee who are to witness the test of axles which is to take place at four o'clock.

Mr. HAYES, Illinois Central Railroad—Mr. President, I move that that Committee be increased to five.

THE PRESIDENT—There are now on that Committee Messrs. Hayes, Forney, Sellers, and Nott.

Mr. SELLERS, of Philadelphia—You will notice, Mr. President, that three of these gentlemen are associate members, while but one of them is Master Mechanic of a railroad. If that Committee be increased, I think it should be increased rather more than is proposed, and that the gentlemen should be Master Mechanics who are familiar with these tests. I think it would be better if Mr. Hayes would name a larger number, so that there will be a sufficient number of the Committee present to make the test interesting.

Mr. HAYES, Illinois Central Railroad—Then I would change my motion by moving that the Committee be increased to ten members.

Carried.

THE PRESIDENT—Before appointing that Committee, I would like to ask the gentlemen if there are any persons who desire to act on that Committee, as I would like to appoint those who wish to witness the test.

Mr. SELLERS, of Philadelphia—The experiments are to be of an interesting character. Axles of both iron and steel are to be broken. I was present at some of these experiments some time ago, and would very much like to see them again, they are so exceedingly interesting.

THE PRESIDENT—I will appoint, in addition, on that Committee, Messrs. Fry, Richards, Wallace, Philbrick, Clark, and Garfield.

Mr. FORNEY, Railroad Gazette—Where are these experiments to be made?

THE PRESIDENT—I will state to the Committee that the parties who have the matter in charge will notify the Committee at the St. Nicholas Hotel, and will make some arrangements with them for getting to the place. As the Committee on the next Annual Meeting were not all present when appointed, I will again announce their names: Messrs. Healy, Eastman, and Bushnell. The Committee on Subjects to be presented at the next Convention are: Messrs. Wells, Boon, J. W. Philbrick, Flynn, and McAllister. By request of Mr. Sedgley the discussion on Locomotive Construction was deferred until Mr. Brooks should be present. Is it your pleasure to take up the discussion of that subject at this time?

On motion, discussion of the report on Locomotive Construction was taken up.

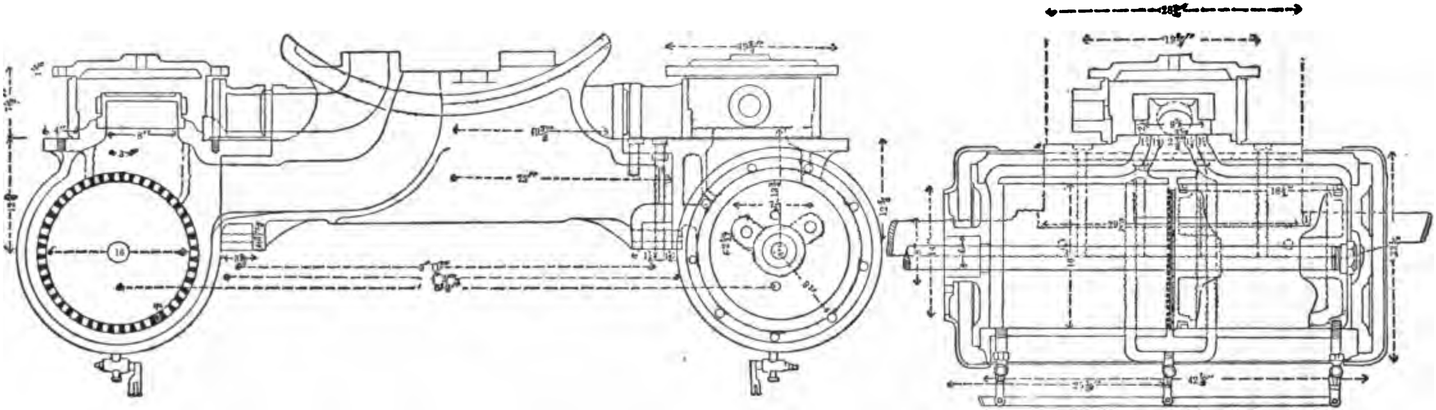
Mr. BROOKS, Brooks Locomotive Works—I am sorry you postponed this discussion on my account. What was the character of the report?

THE PRESIDENT—The greater part of it was a letter that you had written with reference to the Roberts Locomotive, but there was no discussion upon the subject, as the Chairman of the Committee requested that it be deferred until you were present.

Mr. BROOKS, Brooks Locomotive Works—I will say to the members, in reference to this matter of the Roberts Cylinder, that it is hardly yet a question for discussion, but only for information. I am not prepared to recommend it at the present time. I am prepared to say, however, that it develops some new features in the working of steam, as you will readily see when I explain it to you. I have a tracing of the cylinder which I will now show you.

I suppose that many of you understand the general feature of this cylinder, and that the object is to exhaust at a positive point of the stroke of the piston at all conditions of cut-off. We all know that our link motion, unfortunately, is imperfect in this direction, and exhausts prematurely as we shorten the travel and work short cut-off. The Roberts Cylinder is twice the length of the stroke, in addition to all ordinary clearance at each end of piston. Around the circumference of the center of the cylinder is an exhaust belt communicating with the ordinary exhaust chamber below the exhaust port in valve seat; into this exhaust belt is cut a port three-quarters of an inch wide around the whole circumference line of the bore of the cylinder. The piston is made the length of the stroke minus the width of this circumferential exhaust port. The inside lap of valves is made the same as the outside lap in order to prevent the exhaust from escaping in the usual manner, and to retain it for this circumferential exhaust, three-quarters of an inch from the end of each stroke. When the piston has traveled to within three-quarters of an inch from the end of the stroke, it commences to open the central exhaust port, and opens the entire circumference line of the cylinder for the exhaust. Therefore, while with the ordinary cylinder we should exhaust at fourteen inches on a cut-off of seven inches, in the Roberts Cylinder we retain the expansive force of the steam until within three-quarters of an inch from the ends of the stroke. The benefit to be derived from this invention lies in two directions—1st, the perfect freedom of the exhaust; and, 2d, in the positive point of the exhaust so near the end of the stroke at any and all points of cut-off. I am not prepared to argue that this invention will result in a positive improvement and large economy, but it lies in that direction, and unless we find an insurmountable difficulty in the practical construction of the long piston, will undoubtedly prove successful. Of course you will understand there were some difficulties attending the development of this new feature. The first pistons we made weighed four hundred pounds each, and our first experiments were made with these heavy pistons. I believe I mentioned in my recent letter to Mr. Sedgley, and also in my communications to the Railroad Gazette, written some time ago, that before I had opportunities for testing practically the operation of these cylinders, there seemed to

ROBERTS DOUBLE EXHAUST CYLINDER—Brooks Locomotive Works.



Diameter of Cylinder, 16 inches; Stroke of Cylinder, 20 inches; Area of Central Exhaust, 33 11-16 inches.

be two difficulties in the way of success; one, the counterbalancing of the largely increased weight of the disturbing forces; and the other, the immense compression equivalent to the exact boiler pressure, as a resistance at each end of the stroke. These difficulties were, however, merely imaginary. The compression counteracted the increased weight of the disturbing forces, and did not prevent attaining a very remarkable velocity. The engine was at the time of our first experiments (with driving wheels but four feet six inches in diameter and her four hundred-pound pistons) the steadiest riding engine that I ever rode upon at a very high rate of speed, and on her second trip, for a distance of six miles, we traveled right along at the rate of a mile in one minute and two seconds. That this compression was not detrimental, but in this particular case advantageous, is due to the fact that, without it, a large amount of force would be expended in bringing the pistons to the point of inertia. The sum of all the resistances, including the resistance of the load moved, equals the exact force expended upon the steam sides of the pistons; but if the weight of the moving parts, or entire disturbing forces connected with the cranks is not exactly counterbalanced, there is a shock at each end of the stroke, and this shock absorbs a portion of power which might otherwise be utilized for draught or speed. You can not attain a very high rate of speed with a badly-counterbalanced engine with the ordinary valve and method of exhaust; and you may be sure, with these four hundred-pound pistons, the engine was, of necessity, very badly counterbalanced. The present pistons now in use in these cylinders are a great improvement over the first. The entire piston complete, including rod, heads, rings, and every thing connected with it, weighs but thirty pounds more than our standard piston of same diameter. The extraordinary weight of such a long piston seemed to present the greatest difficulty, and this has already been, to a great extent, overcome. Every Master Mechanic knows what evils have grown up with the enlargement of our valves. There is no necessity for this except in the requirements for exhausts. If we can get rid of that necessity of exhausting under the valve, we shall gain a step, and a very long step, in the right direction. While I think this is deserving of a great deal of thought and attention from every Master Mechanic present, I do not believe that any of you need make any experiments with it yet awhile. We have an engine now running a regular train upon the Lake Shore & Michigan Southern Railway with these cylinders. Experiments are now being made with the second set of cylinders. The first set had steam ports one and one-eight inches by sixteen inches; the exhaust ports two and three-quarter inches by sixteen inches; in fact, with the full-sized valve for steam and exhaust, as would have been used to exhaust under the valve, except in the large amount of inside lap of the valve. The inventor insisted upon the necessity of large ports, while I assured him one of the chief advantages to be derived from his method of exhaust, was in the ability to diminish the size of the steam and exhaust ports, and use a very small valve. We do not

require the exhaust under the valve in the Roberts Cylinder, except the instant the valve motion is reversed from one motion to the other. The cylinders now in use have steam ports only one and one-quarter inches by eight inches, and exhaust port opening on valve seat only two and seven-eight inches by four inches, with valve in proportion. The engine may not be quite *so smart* with these cylinders as before, but if not it will be due to the contraction of the central exhaust port which has been drilled on the circumference line from the inside of bore of cylinder into the exhaust belt instead of having an open port as before. The holes are seven-eights of an inch in diameter, and one-quarter of an inch apart; and are to be cut out square so as to present as long a line of first opening as possible. The object of drilling the holes instead of cutting an open port, is to use the segmental packing. That you may have some idea of the explosive quality of this exhaust, I will say here, that we started it with two, three and one-half inch nozzles, the cylinder part of smoke stack being sixteen inches in diameter, and even with these large nozzles, the exhaust was so positive, so abrupt, so explosive in its quality, that it would lift the fire off the grates. Among the twenty thousand locomotives in this country any man could have distinguished this particular engine with his eyes shut, simply by the quality of the sound of her exhaust. In order to overcome the tendency to lift the fire and to soften the exhaust the exhaust nozzles have been increased to four and one-half inches each, and the cylinder part of stack to nineteen and one-half inches at the bottom and twenty-one inches at the top. The velocity of the entering air at the grates is very much diminished thereby and comparatively good results have been obtained. The comparative results mentioned by Mr. Sedgley in his report were obtained by running the engine with Roberts Cylinders in competition with another locomotive, and are, to a certain extent, an unfair comparison, because the latter was in need of general repairs, and especially as her flues were in bad condition. It was, therefore, deemed by both Mr. Sedgley and myself an unfair comparison which should not be brought in here as a basis of comparative economy. I am very careful in regard to this matter, and do not wish this new device to receive any merit to which it is not fairly entitled. It is of no interest to me except as it shall lead to something beyond what we have heretofore attained. There has been no improvement in the efficient economical working of steam in our locomotive cylinders since the introduction of the link motion; and even this was a step backward rather than forward except to simplify the details of valve motion. We all know that it is not the proper way to work steam. We do not want to undertake to work steam expansively, and let it go ten inches from the end of the stroke, if, by any means, we can retain it to within three-quarters of an inch from the end of the stroke and then get rid of it abruptly. We utilize more of our power and there must be a great gain. But I will not detain you longer. I shall be very glad to answer any questions any member

may feel disposed to ask. You have so much to do and so little time, that I feel condemned for occupying so much time as I have.

Mr. FRY, Philadelphia & Erie Railroad—The Chairman of the Committee has asked me to say a few words, in his absence, explanatory of our having introduced Mr. Brook's letter in the manner in which we did. There is always a delicacy with committees in introducing any facts bearing upon patents, but we felt as Mr. Brooks has just stated, that the cylinder that has been described to you was almost the first attempt that has been made with any thing approaching success to improve the working of locomotive engines since the introduction of the link motion, which was introduced by the earliest inventors of locomotive engines. I can only say that I am particularly struck with the extreme modesty that Mr. Brooks has shown in speaking of the invention as far as it has gone. I think that I may justly say that a great deal is due to him in modifying the parts that have tended toward the success of the engine. A great deal of care has been expended upon the engine, and although it happened to be somewhat his patent, I think it is worthy of the consideration of the Convention. We therefore thought that we would submit the letter that Mr. Brooks wrote, and ask him to make some explanation of this invention to the members.

Mr. SELLERS, of Philadelphia—Allow me to ask Mr. Brooks if he has taken any diagrams from the cylinder of that engine yet?

Mr. BROOKS, Brooks Locomotive Works—We have not got to that point yet. There is a time when that will be done, and we are confident that satisfactory results will be obtained. But so far we go by the sense of feeling. I will promise the Convention that if I live another year that this thing shall either be unworthy of the notice of the Convention or else there shall be data furnished, which shall establish the utility of the cylinder. We will find exactly what the condition is on the exhaust side of the piston at the instant of exhaustion, and we will find what the conditions of compression are all the way through the end of the stroke. We will be prepared with full information with regard to it in another year.

On motion of Mr. Chapman, the discussion upon this subject was here closed.

The PRESIDENT—The next business in order is the report of your Committee on "The Best System of Signals for Operating Railroads." The Committee consists of Messrs. Thompson, Underhill, and Ortton. The report is in the hands of the Secretary.

Report on Train Signals.

To the American Railway Master Mechanics' Association:

GENTLEMEN: The Committee, to whom was referred the subject of the "Best System of Signals for Operating Railroad Trains," including Train Head Signals, Train Tail and Side Signals, Switch

Signals, and Appliances for Indicating the Speed of Trains, report as follows:

Circulars were issued embracing the following inquiries:

SIGNALS FOR OPERATING TRAINS.

What is the best system of signals for operating trains of which you have knowledge? Where, and how long have they been in use?

TRAIN HEAD SIGNALS.

Do you know of any better signal than the different colored flags by day and lights by night? If so, please state what they are, how long they have been in use, and the method of using them?

TRAIN TAIL AND SIDE SIGNALS.

What are the best tail and side signals? How are they used upon freight trains? How upon passenger trains?

SWITCH SIGNALS.

What kind of a signal do you use by day? What by night? Do you consider it important that *all switches* in the main track should be lighted?

APPLIANCES FOR INDICATING THE SPEED OF TRAINS.

Have you used such an instrument? Or do you know of one used by others? If so, please state to what part of an engine or train is it applied, and what are the results of its operations?

To these inquiries your Committee has received replies from eleven members only.

To the question, what is the best system of signals for operating trains of which you have knowledge?

Mr. Sedgley, of the L. S. & M. S. Railway, says: "We use red and white flags by day and lanterns of those colors by night."

Mr. C. R. Peddle, of Terre Haute & Indianapolis Railway, says: "We have no system for moving trains other than the use of the bell cord, motions of the hand, or lanterns, and red flags, and lanterns upon the engine and rear of trains."

Mr. Wells, of J. M. & I. Railway, and several others make replies similar to those above named.

Mr. Robinson, of the Great Western of Canada, says: "We use

the general plan of the European and Canada Railways," but does not tell us what that is.

Mr. Thompson, of the Eastern Railway of Massachusetts, reports that, in addition to the signals in general use, they have a system of signals known as "Hall's Automatic Electric Signal," by which trains are operated for a distance of sixteen (16) miles of double track.

These signals were put in operation in 1873, and used at intervals for several months. They have since been improved in their construction and manner of operating them, and for the past nine (9) months all trains have been run between Boston and Salem by them regularly and with entire success.

Your Committee feel that to give a detailed description of these signals and the mode of operating them would trespass too much upon the time of this Convention, but would state, that in corresponding with Mr. Hall, the inventor, he has expressed a desire to, and will, have in New York, during the time the Convention is in session, his complete portable apparatus, with which he has exhibited and explained to special meeting of the Massachusetts Institute of Technology and other similar scientific institutions, and will be pleased to exhibit and explain to the members in part, or to the Convention, his system, as may be most convenient for them.

A complete description of these signals and mode of operating the same may be found in the Railroad Gazette of January 29th, 1875.

On the best system of signals for operating railway trains, your Committee present the following summary of the information obtained by them. That the general practice is to operate all regular trains by schedule time. All irregular trains by a system of using colored flags by day and lamps by night, varying somewhat in the arrangement, but not essentially different.

And the fact that almost the entire operating of the trains of the railways of this country are governed by one or the other of these methods, is evidence that they are sufficient for railways whose business does not exceed their capacity.

There are, however, railways diverging from our metropolitan cities whose trains pass through towns and villages densely populated, requiring trains to be run at intervals of ten (10) and (5)

minutes, and frequently less, making stops at nearly every mile, and often at less distances, where it is evident that in the near future some system of operating trains by intervals of space will be absolutely necessary for their safety.

TRAIN HEAD SIGNALS.

Those in general use are the colored flags by day and lamps by night, placed on front of the locomotive. The exception to the general system is that of the Great Western of Canada, of which Mr. Robinson, Mechanical Superintendent, says: "That we have a very valuable addition to the ordinary head signal, consisting of a system of indicating the numbers of each train by means of changeable metalic figures placed in front of the head lamps. During night-time, red and green-oiled silk screens placed inside of the head lamps, in front of the reflectors, and so fixed on rollers as to be instantly operated by cord connections from the cab as occasion requires. It has one *very valuable* property that it does not necessitate any reconstruction of the lamp, as the whole of the apparatus can be easily attached to it at very little cost."

Regulations for the use of the signals are herewith attached to be read if desired.

TRAIN TAIL AND SIDE SIGNALS.

Of this class, red flags upon the rear of trains by day and red lamps by night, located upon the rear platform of passenger cars and upon the side or top of the caboose cars, are the kinds in general use.

SWITCH SIGNALS.

The common rectangular plate, target, and disc by day; colored lights, green, red, and white at night are the kinds in use.

To the question, do you consider it important that *all* switches in the main track should be lighted? The replies were "yes," at all points where trains are run frequently, and your Committee agree with Mr. Peddle, who says: "That they should be upon *all roads* that aspire to a first class reputation."

APPLIANCES FOR INDICATING THE SPEED OF TRAINS.

Your Committee received replies from three (3) members only who have had *any* experience with such an instrument.

Mr. Sedgley, of the L. S. & M. S. Railway, says: "We are trying Wyth's Speed Indicator attached to the axle of a car, and it appears to possess considerable merit."

Mr. Wells, of the J. M. & I. Railway, has one of "Wyth's" Indicators, and says: "It registers correctly and is perfectly reliable, gives the speed at any part of the line passed over, and the time where stops are made."

Mr. C. R. Peddle, of the Terre Haute & Indianapolis Railway, has furnished your Committee with a comprehensive description of the operation of Professor Wyth's Speed Recorder, also a diagran which accompanies this report. Mr. Peddle has had one in use sufficiently long to test its practicability. The sample diagram accompanying this report is a record taken in doubling seventy-three (73) miles of their road by the instrument, which was so fully described and illustrated in the Railroad Gazette of November 28, 1874, that the Committee do not deem it necessary to give a detailed description of it in their report. Mr. Peddle says: "That the machine gives a complete record of the trip, showing stoppages and backing up of train, and that the only care required is to keep the machine well oiled.

He also says: "That the instructions of their road limit freight trains to fifteen miles per hour, and on applying the instrument they found that they frequently run thirty (30) miles per hour," which is undoubtedly the case on every road in the country.

In closing this report, your Committee suggest: That, in view of the importance of the knowledge obtained through the use of this instrument, furnishing as it does data by which superintendents may be governed in making time schedules, and showing the absurdity of requiring impossibilities to be accomplished by the motive power.

The instrument of Professor Wyth *merits more* than the attention given to it in the report of your Committee.

Respectfully submitted,

JOHN THOMPSON,
A. B. UNDERHILL, } *Committee.*
JNO. ORTTON,

On motion, the report was accepted.

At half-past one the Convention adjourned to meet at three o'clock P. M.

AFTERNOON SESSION.

The Convention was called to order at three o'clock.

The PRESIDENT—If there is no discussion on the last report we will proceed to the next business, which is the report of the Committee on "Locomotive and Tender Wheels." The Committee consists of Messrs. Lauder, Stratton, and Hodgman.

The Secretary will read the report.

Report on Car and Tender Wheels.

To the American Railway Master Mechanics' Association:

GENTLEMEN—Your Committee on Locomotive and Tender Wheels being instructed at the last Annual Convention, held at Chicago, to report breakages of wheels and tires, and cause of breakage or removal, and to report on different methods of construction and manufacturing of various kinds of engine and tender wheels, beg leave to report that they prepared and issued to the Superintendents of Machinery and Master Mechanics of the various railways of the country the following circular:

1. Have any steel tires broken while in use on your road? If so, under what circumstances did it occur? Please give the methods of securing the tire, the nature of the fracture, the probable cause, etc.

2. Have any steel tires on your road been removed from wheels on account of being worn so thin as to be considered unsafe? If so, what thickness were said tires when so removed, and what indications caused you to doubt their safety?

3. Have you in use on your road any driving wheels other than the ordinary cast iron center, with the tire secured by shrinkage? If so, please give the maker's name and also the success you have had with the same.

4. What kind of truck wheels are in use on your road?

5. Have any truck wheels broken on your road? If so, give the maker's name and the probable cause of breakage.

6. Give the number of wheels of different manufacture in use on your road, and the mileage made by the different kinds as far as practicable.

Replies to this circular have been received from gentlemen representing fifteen different railways, and from them we get information as follows:

BROKEN TIRES.

The number of broken tires reported to us for the past year is fifty-seven. Of this number thirty-two were on the Lake Shore & Michigan Southern Railroad; six on the Terre Haute & Indianapolis Railroad; four on the Great Western Railroad; five on the Lackawanna & Bloomsburg Railroad; three on the Boston & Providence Railroad; four on the Boston, Hartford & Erie Railroad; two on the Flint & Pere Marquette Railroad, and one on the Toledo, Wabash & Western Railroad.

There is one case reported by Mr. Graham, of the Lackawanna & Bloomsburg Railroad, that may be interesting to the Association to mention in detail. This tire was of Wm. Butcher's manufacture; original thickness two and eleven-sixteenth inches, had run ninety thousand five hundred and twenty miles, and had been turned once. The inside diameter of wheel was fifty-six inches, weight on each driver ten thousand eight hundred and seventy-five pounds, and tire secured with one-hundredth of an inch shrinkage to each foot of diameter.

The circumstances of its breaking were these: The engineer had knowledge of an extremely bad rail joint in the track at a certain point of the road and had slackened his speed to about twenty miles per hour, and was looking down at the track and saw the tire break when the wheel struck the battered rail joint.

This is an instance well authenticated of a tire of good thickness being broken by a blow.

A large percentage of breakages of tires reported to us were undoubtedly caused by the intense cold that prevailed the past winter and the rigid condition of the road bed. Annexed will be found a table of statistics of tires that have been broken or removed within the past year on the roads that have made returns to us.

REMOVAL OF TIRES FROM BEING WORN OUT.

Your Committee, from information received and from their own experience, are of the opinion that steel tires of good quality will run with safety until they are worn down to one and a quarter inches in thickness in sections of the country where the weather is not extremely cold; but in more northerly sections, where intense cold prevails for several months in the year, we are of the opinion that tires can not be worn thinner than one and three-eight inches in thickness.

METHODS OF SECURING TIRES TO THE CENTERS.

Replies to our circulars are almost unanimously in favor of *shrinkage alone*, allowing one-hundredth of an inch to each foot of diameter of wheel.

LOCOMOTIVE TRUCK AND TENDER WHEELS.

Replies to our interrogatories in regard to truck and tender wheels. have been very meager and unsatisfactory. With a few exceptions, there is no accurate mileage given, owing probably to the fact that few roads keep the mileage of their truck and tender wheels.

Mr. Sedgley, of the Lake Shore & Michigan Southern Railroad, sends a detailed statement of the performance of the passenger car, engine truck, and tender wheels on that road for the past year, which is complete in every respect; and your Committee would recommend that it be incorporated with this report and appear with the report of the proceedings of the Association.

Mr. Peddle, of the Terre Haute and Indianapolis Railroad, reports that the average mileage made by ninety-four pairs of thirty-inch tender wheels removed, was thirty-two thousand four hundred and thirty-five miles, and of thirty-one pairs of engine truck wheels removed, the average mileage was forty-six thousand one hundred and seventy-six miles. Mr. Peddle also states, that classifying the above wheels according to the manufacture, the best average mileage made by wheels of any one manufacture was for thirty-inch tender wheels, fifty-six thousand one hundred and ninety-five miles; for thirty-inch truck wheels, sixty thousand four hundred and fifty-

seven miles, and for twenty-eight-inch truck wheels, thirty-seven thousand eight hundred and seventy-one miles. The mileage made by wheels of the poorest manufacture was for thirty-inch tender wheels, thirteen thousand one hundred and one miles; for thirty-inch truck wheels, forty-one thousand six hundred and forty-nine miles, and for twenty-eight-inch truck wheels, twenty-seven thousand seven hundred and thirty-one miles. Mr. Peddle does not give the name of the maker of any of these wheels, but the figures given above show the folly and want of economy in using a poor wheel because it can be bought a little *cheaper* than a good wheel.

Mr. Weaver, of the Eastern Kentucky Railroad, reports that he is experimenting with wheels made of a mixture of hot blast charcoal iron and steel. They are reported as chilling deeper than the ordinary wheel. He has been running them by the side of wheels made by the Ohio Falls Car Wheel Company for eight months, with a decided advantage in favor of the steel wheels so far. He has not been running them long enough to give any other facts in regard to them.

Mr. Richards, of the Boston & Providence Railroad, reports having in use two pairs of solid cast steel truck wheels made by Bochann, of Prussia. They have been running with scarcely any perceptible wear for two years. He also reports a large number of N. Washburne's steel tired truck wheels in use. He says they are giving most excellent results, and that too much can not be said in their praise. Your Committee regret that he has not given us the mileage of these wheels and their present condition.

Mr. Boyden, of the Boston, Hartford & Erie Railroad, reports having in use a large number of Washburne's steel tired truck wheels, there is no mileage kept, but they are giving excellent results.

Mr. Boyden considers them the most economical wheels he has in use. He also mentions an instance of the breaking of a truck wheel, during the past winter, and ditching the engine. The wheel was made by the Boston Car Wheel Company, and had run but two weeks. The iron looked coarse and rotten, with scarcely any chill.

Mr. Johann, of the Toledo, Wabash & Western Railroad, says that one thousand engine, truck, and tender wheels have given an

average mileage of about forty thousand miles. The manufacturer's name not given.

Mr. Finlay, of the Cairo & Fulton Railroad, reports that two hundred Ramapo Wheels give an average run of forty thousand miles; and one hundred and sixty-eight wheels manufactured by the Missouri Car and Foundry Company, of St. Louis, give an average of twelve thousand miles.

Mr. Hayes, of the Flint & Pere Marquette Railroad, reports using almost exclusively the Ramapo Wheel, and gets an average mileage of forty thousand miles from them. He has had a few break in the flange, some of which showed an unsoundness in the metal, while others were sound and clean. The cause of breakage was evidently from striking a frog point that was out of line.

Mr. Lauder, of the Northern (New Hampshire) Railroad, reports sixty-eight Washburne Steel Tired Truck Wheels in use, forty-four of which are twenty-eight inches, and the remainder twenty-six inches. Of this number eight have failed, after running from thirty thousand to forty thousand miles. Two of the eight broke in the spokes; two were removed on account of the tire becoming loose, and the remaining four were condemned on account of spots upon the tread becoming flat. These wheels that failed were all out of one lot purchased about two and a half years ago, and evidently were of poor material. Wheels purchased before that time, and since, are running as smooth and sound, to all appearances, as when they were first put into use.

Your Committee think that the method of manufacturing these wheels deserves notice. A steel tire first is rolled out, then put into a furnace and heated to a bright red. At the proper time it is taken out, put into a mould, and the molten cast iron is poured inside and brought in contact with the inside of the tire. The molten iron is allowed to run through the mould on the ground until the tire is heated enough to weld. The flow of the metal is then stopped, the mould is allowed to fill, and the cast iron steel tired truck wheel is made.

Below will be found a table of mileage, etc.

NORTHERN RAILROAD OF NEW HAMPSHIRE.

WASHBURN'S	No. of Engine......	No. of Tires........	Weight on Drivers	Weight on Truck..	Size of Truck Wheel..........	Number of Times Turned..........	Mileage..............
Steel Tire Truck..	10	4	37,000	21,690	28 inch.	2	102,525
Do.	27	4	39,050	21,650	28 inch.	2	120,767
Do.	29	4	37,580	22,670	26 inch.	1	62,441
Do.	30	4	38,000	23,200	26 inch.	1	51,750
Do.	31	4	38,200	22,400	28 inch.	0	67,544
Do.	2	4	30,130	18,340	28 inch.	0	43,264

J. N. LAUDER,
G. W. STRATTON, } *Committee.*
S. A. HODGMAN,

Mr. LAUDER, Northern New Hampshire Railroad—The Committee, in their report recommend, as you will perhaps remember, that the table of mileage of wheels on the Lake Shore & Michigan Southern Railway be incorporated in the report. This table contains the mileage made by the passenger car, engine, tender, and truck wheels for the past year. The Committee thought, perhaps, the Association would not care to include the mileage of the passenger car wheels in the report. That is for you to decide. This report is signed by the General Purchasing Agent of the Lake Shore & Michigan Southern Railway, and seems to be complete in every particular, and I have no doubt would give us valuable information if incorporated in the report of the Committee. But it is for the Convention to determine whether the whole amount of mileage shall go in or only that part which relates to locomotive.

On motion, the report was received; and then, on motion of Mr. Lauder, the Secretary was directed to incorporate in the report the Table of Mileage of Wheels on the Lake Shore & Michigan Southern Road.

The PRESIDENT—The subject is now open for discussion.

Mr. WOODCOCK, Central Railroad of New Jersey—I failed to reply to a circular sent me in regard to the tires of wheels, but I would like to state that we removed one set of steel tires on account of their being too thin. I

had them turned some months ago, and then they were one and five-sixteenth inches thick. I thought they seemed sound and tight, and concluded that I would run them still longer to see what the result would be. Those tires were turned some three months ago, and reduced to one and one-sixteenth inches, and put on an engine which has been running some since that time. On taking them off we discovered there was a flaw on the inside of the tire from a hole through which a set screw had been inserted; we found two cracks from those holes out, otherwise they were apparently sound. We thought they were as thin as tires ought to run. I could not get the exact mileage, but it was about two hundred and seventy thousand miles. I do not, however, give that as a correct statement. That is the only set that we have removed of that kind. We have used a number of steel tires on our road, and we had one that was two and one-fourth inches thick break during the Winter into five pieces while the engine was running at a rapid rate. There was no apparent cause for the break, and it is the only tire we have had break.

Mr. Casscaddin, Chicago, Rock Island & Pacific Railroad—I would like to inquire of the gentleman how heavy the engine was on which the thin tires were run?

Mr. Woodcock, Central Railroad of New Jersey—About thirty-eight tons.

Mr. Cascaddin, Chicago, Rock Island & Pacific Railroad—How thick were the tires when first applied to the engine?

Mr. Woodcock, Central Railroad of New Jersey—I can not state the thickness nor the time they were put on, as I was not then connected with the road, and the mileage given is only estimated. All the tires I have put on that class of engines have been two and three-fourth inches thick, and we have adopted that thickness as a standard for that class of engines.

Mr. Cascaddin, Chicago, Rock Island & Pacific Railroad—If the Convention wants to know how many tires have broken, and under what circumstances, I can say that I had two tires broken on engines under my charge; one was two and one-half inches thick, and the other was two inches. I could discover no flaws; the steel looked perfect in every respect. They were freight engines of thirty-eight tons weight. One tire broke in four pieces and the other in two, but without doing any damage to the engine.

Mr. Lauder, Northern New Hampshire Railroad—The Committee on Tires would have been very glad to have had this information about a month ago.

Mr. Cascaddin, Chicago, Rock Island & Pacific Railroad—I expected that Mr. Twombly would represent the Chicago, Rock Island & Pacific Road. I knew that he could do this better than I as he had a statement from me of what my division of the road was doing, and I did not feel like taking the responsibility of answering questions that he had prepared to answer. I supposed that he would be here or I would have prepared a report.

The PRESIDENT—Each and every member of the Committee feels the importance of answers to their questions. If they have those answers in time they can condense them and make a report, and thus get the whole matter before the Convention. It is a matter of great importance that all the records and information be given to the committees.

Mr. LAUDER, Northern New Hampshire Railroad—There is one matter that I hope will provoke a little discussion, and that is in regard to the thinness to which tires can be safely worn before they are taken off. Your Committee has recommended one and one-fourth of an inch as the least thickness that they think can be safely run. I am free to say, however, that I have run them thinner than that, and I presume other members have. If any member has any particular experience or theory about it, I, for one, should be glad to hear it.

Mr. CASCADDIN, Chicago, Rock Island & Pacific Railroad—I would say that if I can not turn a tire and leave it one and three-sixteenths of an inch on the outer edge, my orders are not to leave it on, but I am not permitted to use tires thinner than one and one-fourth of an inch. I do not think it is safe to run a steel tire ordinarily when it is less than one and one-fourth of an inch. If when I take an engine in I find it is going to reduce the tires to less than one and three-sixteenths of an inch, I order a new set to replace them. I have tires, though, that have run as thin as one and three-sixteenths of an inch, and are doing good service now, but it is on light engines of only twenty-two tons weight.

Mr. WOODCOCK, Central Railroad of New Jersey—I rather think that it is not advisable to run a tire down as thin as one and five-sixteen inches as a rule; but we have run them down to one and a quarter inches; but that is an exception. We wanted to test the matter, and only kept them on to see how thin they could be run.

Mr. PEDDLE, Terre Haute & Indianapolis Railroad—I think that it will generally be found the case that when tires are run so thin they will become loose on the center.

Mr. WOODCOCK, Central Railroad of New Jersey—At least two of the six tires had become loose after they had run for some length of time, but rivets were put in them, and then they were run on till they were renewed.

Mr. SETCHEL, Little Miami Railroad—I think it depends, in a great measure, upon the time of year when these tires are turned. A tire one and a quarter inches would not be any more durable, in my opinion, in hard-freezing weather when the track is rough, than an inch tire would be in warm weather. It seems to me that a tire an inch thick with a flange about one and three-quarter inches is ample in warm weather, unless the train is very fast, and on freight engines and on accommodation trains, not of high speed, an inch thick with a good flange is just as safe as one and one-quarter inches in cold weather.

Mr. HILL, Erie Railroad—There are a number of Master Mechanics pres-

ent from whom I would like to hear in regard to this matter. We have one set of tires that deserves mention, and as none of our Mechanics have seen fit to refer to it I will do so. Engine No. 2 was transferred from the Northern Railroad to the Erie Road in 1869. At what time the tires were put on, and of what thickness they were originally, we have no record. Those tires were run on that engine until eight months ago, when they were turned down to seven-eighths of an inch in thickness, and they are still running and perfect. The engine is running on an average of one hundred and twenty-five miles a day. Mr. Krupp heard of those tires, and has asked that they be shipped to him when taken off. I believe that is as thin as a steel tire ought to run.

THE PRESIDENT—What is the heft of that engine?

Mr. HILL, Erie Railroad—About twenty-six tons. It was built by Danforth, Cook & Co.

Mr. CASSCADDIN, Chicago, Rock Island, & Pacific Railroad—I would like to ask Mr. Hill if he would recommend running them less than that?

Mr. HILL, Erie Railroad—No, sir, I would not; I think that is an exceptional case.

Mr. CASSCADDIN, Chicago, Rock Island, & Pacific Railroad—I think that cold weather has a great deal to do with the safety of the tire, but I think when a tire gets down to one and one-quarter inches with a heavy engine and a rough road, it will be very apt to draw loose either in winter or summer. I should not like to run a tire less than one and one-quarter inches thick.

Mr. HILL, Erie Railroad—We have several sets of tires running that are less than one and one-quarter inches.

Mr. WILDER, Erie Railroad—I think that the quality of the steel has a great deal to do with the durability of the tire. We had one tire break this winter that was two and three-quarters inches thick, and it broke without any apparent flaw through the cross section. We have had other tires run until they were but one and one-sixteenth inches.

Mr. CASSCADDIN, Chicago, Rock Island, & Pacific Railroad—I would like to inquire how much shrinkage there was in the tire that broke at two and three-quarters inches thick?

Mr. WILDER, Erie Railroad—I can not say. It had then run two years, and had passed through one winter previous to breaking. The engine was built at Brooks Locomotive Works, and I believe that they generally put one-sixteenth of an inch shrinkage to a five-foot wheel.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—I have had occasion to remove, perhaps, five sets of steel tires within the last three years on account of their being worn out, and I found that they all became loose on the center when they were worn down to one and one-quarter inches, and some of them at one and three-eight inches. After they were lined up and turned off, they then ran until they were one inch thick in the center.

One set was only seven-eights of an inch thick, and had not then become loose. I presume that one and one-eight inches is as thin as we can calculate to use tires. Under heavy engines probably one and one-quarter inches is as thin as it is safe to run, but on light engines, perhaps, the tires can be used safely when not more than an inch thick.

Mr. WOODCOCK, Central Railroad of New Jersey—I would like to know something about the average mileage of steel tires on truck wheels.

THE PRESIDENT—That was embodied in the report in a table which was not read, but will be printed with the report.

Mr. WOODCOCK, Central Railroad of New Jersey—We have quite a number of wheels that do not come up to our expectation, and we would like to see how they compare with others. I was speaking to the inventor of the process, and he said that a good steel-tired truck wheel should make two hundred thousand miles if they were properly made.

Mr. ROBINSON, Great Western of Canada—I would like to have some of the members tell me the action of the steel tires after they break, those that are not secured by any means except shrinkage. The report does not say whether any damage resulted from the breakage.

Mr. LAUDER, Northern New Hampshire Railroad—I do not think that there was any information given of any damage done. A large proportion of broken and removed tires were obtained from the Lake Shore Road. It was given in the form of a table without any details.

Mr. GRAHAM, Lackawanna & Bloomsburg Railroad—I gave the particulars concerning the breaking of the tires that I reported to the Committee. There was no damage, the tires remaining on the wheels when they broke. I mentioned one in my report that was broken by striking against the end of a bad joint. The engineer happened to be looking down at the time, and his eye caught the rail before the wheel came to it; he immediately stopped, and as I happened to be on the train, I went forward to see the fracture. It was a clean break all the way through but no other damage was done.

Mr. LAUDER, Northern New Hampshire Railroad—I think that Mr. Graham did state that there was no damage done, but it was not thought necessary by the Committee to state that fact. If there had been any damage done, of course, it would have been stated.

Mr. ROBINSON, Great Western of Canada—This is very much like the steel fire box. It shows how different we are from the European practice. Both in England and on the Continent, you find it an exception to have steel tires set without having them secured to the wheel by a flange, or by set screws or by some other means; whereas, in this country the opposite practice, having no security except the shrinkage, seems to be in vogue. An English railway company would be frightened to run an engine the way that we do here. It is the same with steel fire boxes. One country has taken one direction with regard to a certain practice, and another the opposite. We shall see which comes out best in the course of time.

Mr. WILDER, Eire Railroad—In regard to fastening tires to the wheels by some method of set screws or rivets, I will say that among the different tires that we have broken during the Winter, the one that I spoke of was not fastened in any way but by shrinkage. The engine ran from Suspension Bridge to Buffalo with the broken tire in its place. Another that we had broken (and which was, I think, one and three-eighth inches thick), was secured by set screws. The tire slipped around on the end of the set screws, and the weight of the engine drove them back and broke out the holes. It broke out the casting so that it spoiled the wheel. We had some damage happen to another engine that had set screws. I do not see that they do any good in holding the tire and there is danger of spoiling the wheel.

Mr. CASSCADDIN, Chicago, Rock Island, & Pacific Railroad—That reminds me of something that I forgot to state in regard to the tires that I mentioned. It was two and a quarter inches thick and broke through the countersink, for the end of the set screw which held the tire, and all four of the breaks were across and through these holes. The hole in the center where the drill run in was five-sixteenths of an inch deep, and at the outer edge about three-quarters.

On motion of Mr. Robinson, the dicussion on this subject was closed.

THE PRESIDENT—The next business in order is the report of your Committee on the "Construction and Improvement of Continuous Train Brakes, and their Application to Cars and Locomotives." The Committee consists of Messrs. Peddle, Gould, and Richards. The Secretary will please read the report:

Report of Committee on the Construction and Improvements of Continuous Train Brakes.

To the American Railway Master Mechanics' Association:

GENTLEMEN—In pursuance of the object of their appointment, the Committee prepared a circular for distribution containing nine interrogatories, to which exactly nine replies were received from Master Mechanics having continuous brakes in use. Brevity was a marked feature in most of these replies, and as the Committee find themselves deficient in the quantity as well as the quality of the raw material with which they have been furnished, they ask the indulgence of the members of the Association if the report submitted by them is not commensurate with the importance of the subject confided to them.

The Westinghouse Air Brake is in use upon all of the nine roads from which replies were received. The advantages claimed for it are

common to all continuous train brakes, and may be summed up as follows: The engineer has entire control of the train, as he *should* have; fewer cattle are killed; better time is made by reason of quicker stops, and accidents from collisions or other causes are avoided or mitigated. The only disadvantages mentioned, are: Cost of maintenance and defects in the reversing apparatus of the steam cylinder which compresses the air, which, however, has been modified and improved in the apparatus as now constructed.

The cost of repairs per engine, exclusive of casualties, is returned by five roads as follows:

Cleveland & Pittsburgh	$87 00
Vandalia Line	41 03
Eastern Railway	37 50
Little Miami	22 68

Great Western, of Canada, 5.8 cents per one hundred miles, which, at a yearly mileage of thirty thousand (a fair estimate for a passenger engine), amounts to $17 40 per year.

Only two statements were made of the cost of maintaining the brake on passenger cars, viz.:

Eastern Railway	$4 35 per car per year.
Vandalia Line	4 65 per car per year.

Mr. Robinson states that the expense is so small that it is not separated from the other car repairs.

To the third question Mr. John L. White replies as follows: "Upon one occasion a hose burst when the air was turned on suddenly, by which the brake was made useless, and in consequence the train ran into a misplaced switch and collided with a freight train on the siding."

To the fourth question Mr. White also furnished the following reply: "In one instance a passenger train, running at the rate of forty-five miles per hour on a slight down grade, was stopped within seven hundred feet with engine shut off, but not reversed. At another time, running thirty-five miles per hour down a forty-foot grade, stopped within six hundred feet, saving a collision with cars on a side track, switch being wrong. On another occasion, running at the rate of thirty-five miles per hour in foggy weather, up a thirty-foot grade, stopped in three hundred feet, and avoided a collision

with a freight train which had broken in two. At another time there were two horses in a bridge, train running twenty miles per hour, and stopped in one hundred and eighty feet. The engines were reversed in every case except the first one mentioned."

Mr. J. H. Setchel furnishes the following interesting items of his experience: "The writer has had an experience in saving a passenger train, that demonstrated conclusively to his mind, the importance of reliable continuous train brakes. A little over a year ago, having occasion to run an express passenger train, on account of a little unpleasantness with the engineers, as he was nearing the suburbs of Cincinnati, and running at from twenty to twenty-five miles per hour, a switch was discovered to be wrong. The air brake was instantly applied and the engine reversed, but some cars in the siding were struck, and the first one split in halves, and the others knocked some distance, and into a house. The smoke stack of the engine was knocked off, and the front end and pilot were badly broken; but the passenger train, although running on a sharp curve where it might have been expected that a fearful wreck would be made, was completely saved by the prompt application of the air brake—only one coupling in the train being broken. The switch had been purposely changed, where a spur track ran off from the inside of a sharp curve into a lumberyard. The distance from where the switch could be seen, to where the cars stood, was three hundred and fifty feet. Many other cases might be given where the air brake has been of signal service in saving life and property; but I will only give you two, both occurring to the same train and engine, and on the same trip. The first was caused by a broken rail, which threw the front truck of the third car from the track, in the immediate vicinity of a cattle guard. The train was running twenty miles per hour, and had six cars. The engineer says: 'We stopped within four hundred feet after the alarm was sounded, with but little damage to the train.' The second was caused by a broken axle in the front truck of the ladies' car. The train had now four cars, and was stopped before any material damage was done. The weather was very cold, the thermometer standing at eight degrees below zero. In these cases, that much suffering and destruction of property was avoided by the use of the air brake, there can be no doubt."

In answer to the fifth question, Mr. J. Johann, of the Toledo,

Wabash, & Western Railway, reported that the improved Automatic Brake is in regular use on that line, and that he considers it a very essential feature.

Mr. John Thompson replies as follows: "We have two of the Automatic arrangements put on our trains with which we made the experimental tests, which were highly successful, showing a great superiority, in the tests made, over the ordinary arrangements. The Automatic apparatus is not in use now, by reason of the burning of an entire train, while standing in the shed, with all the apparatus. The use of the other was discontinued for the reason that it is too complicated to warrant the continued use of it, while the ordinary arrangement answers the general requirements as well; in other words, it would be a question whether the apparatus, not being in daily use, could be kept in working order, ready to meet extraordinary emergencies, unless it was made a substitute for the original; my opinion is that it would not."

Mr. G. Richards replied that one train on the Boston & Providence Railroad is equipped with the Automatic Brake, but for general purposes he preferred the other.

Mr. W. A. Robinson replied: "We have one set of cars fitted with the Automatic principle, which meets all the requirements. I consider this an important feature in a continuous brake system."

Mr. Reuben Wells replied as follows: "Except in cases of trains running at high speeds, or crowded roads, it is my opinion, considering the complication of the apparatus, and the difficulty in keeping all parts of it in perfect working order, that it is, on the whole, *not* desirable."

From the fact that one member only of the Committee has actual experience with the improved brake, they will not express an authoritative opinion upon its merits; but, at the same time, admit that it is a very ingenious mechanical contrivance. A more extended trial upon the roads now using it will demonstrate its actual worth.

The general tenor of the replies to the sixth question was, that, if the air cylinders are regularly cleaned and lubricated, and if the brake is properly manipulated by the engineers, there is little or no trouble in starting up a train after a stop has been made. Crude petroleum is recommended as a lubricant for the piston leathers. One member of the Committee experimented with a release valve attached

to the car cylinders, which permitted a sudden exhaustion of the air from the cylinders the moment the pressure decreased in the air pipes, but found that great care was required by the engineer using the brake to prevent a disagreeable concussion of the cars of the train, and that in descending long and steep grades where a frequent application of the brake was required, so much air was allowed to escape as to make it difficult to keep the pressure up to the working point, and its use was finally abandoned.

The answers to the seventh question were generally to the effect, that, the durability of car wheels, under the application of the air brake, is as great, if not greater, than with the old hand-brake system. This, however, is a difficult question to settle, unless where the wheels are manufactured by the railroad companies using them, and the mixture of iron used is known, as the quality of wheels from different makers, and from the same makers at different times, is constantly varying. The ability to make quick stops at stations without any particular exertion on his part, is a strong temptation to the engineer to use this power to its extreme limit, and under the varying conditions of weather and load in train, the wheels are frequently slid without his being aware of it. This is especially the case with tender wheels upon which the load varies from ten to twenty tons. The Committee are, therefore, unwilling to concede that a greater service can be got from car and tender wheels by the use of power brakes as compared with the old hand brakes, unless more reliable data can be furnished.

The respondents to the eighth question suggest no improvement which would make the air brake more effective or less costly in maintenance.

To the ninth and last question, Mr. William A. Robinson replied that the brake had been applied to the drivers of one freight and one passenger engine, and was doing well, but no special experiments had been made to test its efficiency. Mr. Johann, also, had one engine fitted with the brake, and he considered it a valuable auxiliary to the train brake, but gave no particulars.

This finishes the subject as far as the information derived from the replies to the circulars carries it. The very full critical report of the Committee of last year upon the different systems of brakes in use, renders it unnecessary for this Committee to go over the same

ground. In the main they indorse the conclusions of the Committee as to the superior advantages of the Westinghouse Brake. They are of the opinion, however, that the air brake of the future must combine equal efficiency with a cheaper and simpler compressing apparatus; and whether that object can be best attained by a donkey pump, or by utilizing the working machinery of the locomotive, or the momentum of the engine and train, is the problem to be solved. Within the past eighteen months two new inventions have been brought before the public, which make use of the steam pressure to produce the power, and water or some non-freezing liquid to transmit the power to the brakes under the cars. One of these inventions is known as "Henderson's Hydraulic Brake," and the other as the "McBride Hydraulic Brake." The former has been in use for about nine months upon the Westchester & Philadelphia Railroad, a small road in Eastern Pennsylvania; but the other, we believe, has not reached the experimental stage as yet. A brief description of the Henderson Brake, taken from the circular of the company, will answer for both, as they are on the same principle, though differing somewhat in the details, McBride having appropriated the Westinghouse car fixtures complete, as shown by the wood cut of his in his circular.

"Between the wheels of each truck there is placed a cylindrical vessel of cast iron, whose ends are formed of two dish-shaped flexible diaphragms of India rubber, secured to the drum, and making an air-tight joint at the periphery by flanges bolting thereto. Two rams, working in opposite directions, are fitted against and into the hollow part of the diaphragms; their outer ends are attached by rectangular flanges and bolts to the brake beams carrying the brake shoes. The several castings are simply bolted together, with the diaphragms as they come from the foundry, without recourse to the usually expensive mechanical fittings.

"When pressure comes between the diaphragms, it simply forces them apart, projecting the rams, which act immediately on the brake beams, applying the brakes; and when the pressure is relieved the atmosphere reacts on the area of the rams and forces them back, assisted by the tendency of the diaphragms themselves to recover their normal condition. The peculiar construction of this device, it will be seen, possesses all the requirements of a cylinder and working piston, as well as recoil springs. All piston packing and stuffing

boxes are dispensed with, and no lubrication is reqired; the interior is sealed from dust, all complications of levers and rods and attendant lost motion is done away with, and its operation is free from all connection with the usual hand-break gear, which remains as efficient as before. When the brake shoes are arranged on the outside of the wheels, as on the Westchester & Philadelphia Railroad, one of the rams and diaphragms is dispensed with, and the casting is bolted directly to the outside of one of the brake beams. Action and reaction being equal, when pressure is applied the casting presses one way and puts its brakes on, and the ram going outward draws the opposite brakes on by means of two rods attached to the head of the ram, and connecting with the other brake beam. The power is derived directly from the boiler of the locomotive; we have, therefore, at our command the same power to stop the train which is used to impel it forward. The device employed to transmit this power to the pressure boxes just described, consists of an hydraulic press operated by a double-acting steam cylinder, the valve of which is worked by the hand of the engineer. There is a piston in each; steam actuates the one to force the water from the other, thus creating hydraulic pressure on the pressure boxes, and to withdraw the same to release the brakes. An air cushion is provided above the press piston to prevent striking the heads when coming back light. The press receives water from a tank, which may be the engine tank, or a special tank, provided for the purpose, through a pipe furnished with a check valve opening toward the press cylinder, in such a manner that the fluid can not return to the tank. For low temperatures a mixture of equal parts of glycerine and water is used in lieu of water, which is safe to thirty degrees, Fahrenheit, below zero. Iron pipes are used under the cars with flexible hose between them, furnished with hydraulic couplings, which it is obvious must be tight, both with and without internal pressure, a peculiarity possessed by this coupling alone."

The Committee hazard the opinion that a fluid like water, devoid of elasticity and liable to freeze at a low temperature, will hardly be able to supersede compressed air as a transmitter of power to continuous brakes. It requires a considerable amount of power to overcome the inertia of a long column of water and put it into a rapid motion, and also to check that motion suddenly, and such operations

are always accompanied by concussion or "thumping" in the machinery used, unless mitigated by a cushion of air, as in the familiar example of the air chamber placed on the suction and delivery pipes of pumps. Any medium, then, which is sluggish in its action, and when finally put in motion imparts the full pressure suddenly to the brake shoes, is not so desirable as one which can be put in motion *instantaneously*, but which *gradually* brings the pressure up to the maximum.

In the circulars issued by inventors of brakes, much stress is laid upon their ability to make short stops with their peculiar kinds of brake. Now, the old Loughridge Friction Brake made as good a record in that respect as any of its successors, but the application of the brake communicated a sudden shock to the cars, which was any thing but agreeable to the passengers, and, in fact, sometimes emptied the seats. The great advantage of the air brake is, that this sudden shock is avoided without the efficiency of the brake being impaired. The movement of the brake blocks should be simultaneous, or nearly so, with the application of the pressure, and the release of the same by the engineer.

It may not be out of place to state a simple *rule* for determining theoretically the retarding power of a good continuous brake, as a means of comparison with actual reported results.

Let us suppose that a train, consisting of an engine weighing thirty tons, with a tender weighing twenty tons, and six cars weighing twenty tons each, in all one hundred and seventy tons of two thousand pounds, is running at a speed of forty miles per hour on a straight and level track. It is required to know the distance in which said train can be brought to a state of rest, and the time consumed, after shutting off steam and applying the brakes which are assumed to be fitted to the tender and six cars. A speed of forty miles per hour is equivalent to fifty-eight and seven-tenths feet per second, and by the law of gravitation a body projected vertically into the air with an initial velocity of that amount will ascend fifty-three and a half feet before it is arrested by the force of gravity. Similarly a railroad train moving on a horizontal track at the same speed will be brought to a state of rest after shutting off steam, if a retarding force can be applied equal to its own weight. The resist-

ance of the atmosphere is not taken into account in either case at present.

Now the retarding forces available for stopping a train, are the friction of the brake shoes upon the wheels, the axle friction, the rolling friction of the wheels upon the track, and the resistance of the atmosphere. The brake friction bears a certain proportion to the pressure applied, and varies somewhat with the condition of the weather, but one-sixth of the pressure applied, may be considered a fair average allowance.

The pressure upon the brakes is limited by the weight on the wheels fitted with brakes, and the weight on the wheels must *always* exceed the sum of the brake pressure and axle and rolling friction to prevent sliding of the wheels. If we allow one ton for axle and wheel friction, to be on the safe side (it is actually less than one-half that amount), it will leave one hundred and thirty-nine tons available for brake pressure, and one-sixth of this, twenty-three and one-sixth tons, or forty-six thousand three hundred and thirty-three pounds, will be the brake resistance. To this we must add the axle and rolling friction, and the resistance of the atmosphere, which at the speed indicated, may be set down in the aggregate at fourteen pounds per ton of train, or two thousand three hundred and eighty pounds, and the total resistance will then be forty-eight thousand seven hundred and thirteen pounds, or one-seventh of the weight of the train. If, as before shown, a train will run fifty-three and a half feet in one and eighty-two one-hundredths seconds if the retarding force is equal to its own weight, it will run seven times that distance, or three hundred and seventy-four feet, if the retarding force is one-seventh of that amount, and will consume about thirteen seconds of time.

But this calculation is based on the supposition that the full brake pressure is applied at the instant of shutting off, which is *never* the case in practice.

With the original Westinghouse Brake, three or four seconds are usually consumed in getting full brake pressure upon a train of six cars, and it will be safe to assume that a distance of one hundred and sixty feet will be passed over before the full effect of the brake can be exerted, and if this distance is added to that previously given the total distance run after shutting off and applying the brake,

will be ~~two~~ five hundred and thirty-four feet, and the time required may be roughly stated as sixteen seconds.

The Committee regret that no report was received from members using the Smith Vacuum Brake. Considerable interest was manifested in this invention at the last meeting of this Association, and its chief merits, simplicity of construction, and low cost of maintenance were duly set forth; but although it is in regular use on thirteen prominent railroads, the Committee has not been furnished with a scrap of information in regard to its working during the past year. From published reports, it appears that the Westinghouse Air Brake is in use upon one hundred and ——— railroads in this country. This successful result is to be attributed to the business energy and tact of its inventor no less than the intrinsic merits of the brake. The Smith Vacuum Brake is in use, as stated above, upon thirteen, and the Loughridge Air Brake on two prominent lines in this country. No information in regard to the other brake systems has been received by your Committee.

All of which is respectfully submitted.

CHARLES R. PEDDLE,
F. GOULD,
G. RICHARDS, } *Committee.*

On motion of Mr. Casscaddin the report was accepted.

THE PRESIDENT—Discussion upon this subject is now in order.

Mr. WOODCOCK, Central Railroad of New Jersey—I would state that our road is using the Vacuum Brake, we have it on fifty-nine engines and one hundred and seventy-two cars. The brake is giving entire satisfaction. We have used it since July, 1872. It has never failed, and from all the information I can get it is doing its work satisfactorily. We like it for its simplicity, its effectiveness, and because it costs much less to keep it in repair than any other. As near as we can figure on the expense of keeping it up, it is about $4.22 per year per car, and $9.55 per engine.

Mr. HUDSON, Rogers Locomotive Works—I have only a word to say on the subject of brakes. I learned that within the past twelve months the Vacuum Brake Company have sold out their interest to the Westinghouse Company. In conversation with Mr. Westinghouse in relation to an order that we had for a Vacuum Brake for South America, I learned that he recommended decidedly the Westinghouse in preference to the Vacuum Brake, and claimed that it was very much superior. Of course that is very natural for him; we, however, might not come to the same conclusion. He

stated among other things to me, that from their own experience they found it better to use wrought iron brake shoes on tired wheels, and cast iron brake shoes on cast wheels; and that the result was the wheels were not so liable to break where the brakes were in continuous use. In other words, a cast iron shoe did not impart as much heat to a cast iron wheel as a wooden block would. That is an important matter, especially in a country where they have to use the brakes for thirty miles in succession on a continuous down grade of twelve hundred feet per mile. The brake shoe that will do the business with the least detriment to the wheel is to be preferred. I presume that some gentlemen here have experience as to the best material for brakes and brake shoes, and I would like to hear their opinions or experience to learn whether it corresponds with the information obtained by me from Mr. Westinghouse.

Mr. Chapman, Cleveland & Pittsburgh Railroad—I would state that for a year past we have been using upon our passenger trains malleable iron brake shoes, made very much lighter than ordinary cast iron, and with very good results. They wear much longer and give much better satisfaction than cast iron brake shoes.

Mr. Wells, Jeffersonville, Madison & Indianapolis Railroad—I would like to ask Mr. Chapman how the cost of malleable iron compares with the cost of cast iron in rendering the same service; whether it is cheaper to use malleable iron than ordinary cast iron?

Mr. Chapman, Cleveland & Pittsburgh Railroad—We find it cheaper to use the malleable iron—the malleable iron weighing a little less than one-half what cast iron does—costing about three times as much, and wearing about four times as long.

Mr. Casscaddin, Chicago, Rock Island, & Pacific Railroad—I would like to ask if there is any other member here than the one who has already spoken for the Vacuum Brake who can give us further information in regard to it? I have been using the Westinghouse, and I think it has been rather expensive; but as I have not used the Vacuum I can make no comparison.

Mr. Hollister, Lebanon Valley Railroad—Our road has been using the Vacuum Brake for the past year on twenty cars and six engines. We have had no expense to incur except, occasionally, for replacing a hose which has been broken off.

Mr. Graham, Lackawanna & Bloomsburg Railroad—I would state that we put the Vacuum Brake on six engines and a hundred cars last fall, and we have had no expense attending it since with the exception of some hose that was pulled apart by pulling the pin out without disconnecting them.

Mr. Peddle, Terre Haute & Indianapolis Railroad—It would have been a great deal more satisfactory to the Committee if we could have obtained this information in time for the report. There were only nine reports made to the Committee, and they were very limited in extent. I think that the object of these Committees is to get the actual experience of members so that

we can have something reliable in the reports. We attempted to get the cost as far as we could, but the reports were very meager in that information. Now the gentlemen say that they have had the Vacuum Brake in operation; that it runs first-rate, and costs nothing, etc.; but they did not give the Committee any information about it.

THE PRESIDENT—I do not blame the Committee for rubbing the ears of all these parties who speak on this subject for not answering the circulars, but I hope that will not have any influence in restraining parties from speaking of it in the Convention. I hope that we may get the experience of all the members who have used any kind of brake, in order that we may place upon record what we know to be the facts with regard to them all; such information will be of value, not only to this Association, but to the whole country; and it is, therefore, our duty to state all the facts.

Mr. SETCHEL, Little Miami Railroad—I was in hopes that the members would take up this subject as readily as they had done the subject of boilers and boiler materials. For I think that it is only second in importance to that subject. I believe that, so far as our own road is concerned, it is the unanimous opinion that we could not afford to do without the continuous train brake. We have in use the Westinghouse Brake on sixty cars and twenty-three engines; and I must say that I was quite surprised to see that the expense was so light as it proved to be. Immediately after the Chicago Convention I gave orders to have an accurate account kept of all the material used for engines, and gave the result to the Committee. I am not satisfied with the action of the air pump of the Westinghouse Brake. I think it might be made more simple and less expensive. I can not see why the Westinghouse people will persist in using that expensive pump, unless it is to keep up an appearance which will justify the enormous price they ask for the use of the brakes. Every member here knows very well that there is ample opportunity of placing upon the locomotive an air pump in almost any position that you desire it, and which could be worked by the engine when in motion. The objection made to this is, that you must always have air stored up in your reservoir. That I do not consider a sufficient objection. If your reservoir is tight it needs only a stop cock to be turned upon the pipe leading to the reservoir to maintain as much pressure as you need at all times. That would be just as simple as it is to turn the three-way cock in the Westinghouse Brake. A sufficient pressure could thus be maintained at all times, and the reservoir of air could be kept while the engine was standing in the house as well as on the road; and thus we will always have a sufficient amount of air to stop the train. By this arrangement the expense of equipping an engine would be twenty-five per cent. less than what it is now—I mean for the pump alone. The Loughridge Air Brake which has been adopted on the Baltimore & Ohio Road, as I have been informed by engineers that have run it, involves no expense whatever except for the oil used upon it. It is a much simpler arrangement, and it seems to me that the members of the Con-

vention ought to give a decided expression of their opinion in favor of something that is not so expensive as the Westinghouse Pump.

Mr. LANNON, Western Maryland Railroad—I would state that since last February we have been using the Loughridge Brake. We have it on three engines. Two trains are fully equipped with it. The expense of equipping an engine and train is very little. We find no difficulty in retaining air in the reservoir over night. We go into the engine house with seventy-five or eighty pounds of pressure in the reservoir. We put the stop cock as close to the reservoir as we can get it, and when the engine is put away—say at night—this is closed, and in the morning when we come out on the table the cock is opened, and we find by the air gauge that we have not lost over three pounds during the night. The pump and reservoir cost us about $80. The reservoir contains thirteen cubic feet. It has given us no trouble; in fact not as much as the ordinary hand brake that we were using before adopting this. We had not been using this brake long enough to answer Mr. Peddle's circular, and that is the reason I did not. I met Mr. Loughridge in Baltimore on the morning I was coming away, and he told me that he had written to Mr. Peddle with regard to the matter, and also gave him a challenge to lay before the Convention.

Mr. PEDDLE, Terre Haute & Indianapolis Railroad—Mr. Loughridge sent me a paper, but I received it too late for the report. He gives a challenge to all parties to meet him in the Centennial Exhibition and run against his brake. He proposes to equip ten cars with his brake and run against any other brake manufactured—they using ten cars also—so as to test the thing fairly, and taking a week for it if necessary. If the Convention desire it I will send the letter to the President to be read to the Association.

Mr. LANNON, Western Maryland Railroad—I would further state that it required no other springs to throw off the brake from the wheel than the springs that we were using for the ordinary hand brake. We have no trouble in starting the train on our hardest grades, and we have some of ninety-five feet to the mile.

Mr. ROBINSON, Great Western of Canada—I would like to ask the members who are using the different air brakes whether they use them on freight as well as on passenger cars; and, if so, whether they experience much trouble with the temporary pipes that have to be used? On the Great Western Railway we are very much pleased with the Westinghouse Brake, and we have had no trouble with it. It has given great satisfaction. But our line being a link between other railways, we frequently have foreign cars passing over our road, and under these we have to connect India-rubber pipes temporarily, and take them off again at the end of two hundred and thirty miles. The expense of these pipes, because of the frequent breakage, is greater than all the other, but can not be charged to the air brake. Ours is, probably, an exceptional case, but I mention it thinking that the information may be useful.

Mr. YOUNG, Cleveland, Columbus, Cincinnati, & Indianapolis Railroad—I would like to inquire if any members are using the Driving-wheel Brake; and, if so, what the result has been?

Mr. ROBINSON, Great Western of Canada—We have one on a passenger engine, and one on a freight engine, but I have been so busy that I have not paid any attention to it. It is a very powerful agency, and I think it represents the brake of two or three cars put together. It brings the train very quickly to a full stop. That is all that I can say about it. I understand that the Pennsylvania Railway has, or is going to have, a large number of freight engines fitted up with this brake, and, perhaps, the members from that company can give us some information about it.

Mr. STRATTAN, Pennsylvania Central Railroad—There are a large number of engines being fitted with driver brakes on the Pennsylvania Railroad, a few of which run to Altoona; but they have been in service so little that no definite results have been obtained yet. The brake is applied either by levers or by cones to the drivers. I have ridden only twice on engines having a driver brake, but the elasticity of the air in the cylinder seems to compensate for the vibration of the brake over the drivers. My anticipation was that the brakes would be held up against the drivers rigidly; but the elasticity of the air in the brake cylinder seemed sufficient to make connection easy. The brakes have not been in use long enough to give decided results; but so far there has been no complaint. We first thought that the application of leverage between the wheels would strain the axles in the opposite directions, as against any wear that might occur in the boxes, but it does not seem to have that effect. The rods can be run with driver brakes equally as tight as without them. Not having to hold the momentum of the engine by brakes on the cars, looks as if it would result in benefit to the car wheels. Although we were in some doubt about the utility of the brakes when we first applied them, they are gradually gaining in favor.

Mr. ROBINSON, Great Western of Canada—I would confirm what Mr. Strattan has said. I was afraid of the side draw of this driver brake, and for that reason I had only one put on at first, that I might give it a trial. I thought there would be a severe action on the springs and also on the side rods; but it is as Mr. Strattan says, the action is entirely counterbalanced. It is simply the wheel brake acting against an air brake. We run at a very high speed and came to a full stop, but there was no jerking motion. The brake has been in use over nine months. Mr. Setchel mentioned something about the Westinghouse Air Pump. I was told the other day that the Westinghouse Company was getting up a new air pump, simpler and very much cheaper to maintain, and stronger in all its parts.

Mr. WILDER, Erie Railroad—I would like to ask the gentlemen who have had experience with this brake, what effect it has upon the tires of the engine?

Mr. ROBINSON, Great Western of Canada—I prefer to have the tires fast-

ened, but if they are loose I should not think the brake would have any ill effect.

Mr. STRATTAN, Pennsylvania Central Railroad—I do not think that driver brakes have been used long enough to obtain satisfactory results; but the brake can be applied easily, so that its action on the tire will not have bad effect. It is possible, however, to put the brake on instantaneously and cause a very sudden jar. Injury can be done in that way. It is like the starting of an engine. It can be done easily or quickly. I had occasion to note, at the beginning of this month, in making a summary of our doings at the Altoona shop, and reporting to the Superintendent of motive power, that on engines running to Altoona from each direction, there was only one during the month of April without air, and that was for the distance of only six miles running west of Pittsburgh. A set screw on the tie plate of the pump became loose, and the consequence was that the engine ran that short distance without air. So far as our experience goes, I think we may consider that we have a perfect working pump.

Mr. WOODCOCK, Central Railroad of New Jersey—The question with regard to the wear of tires by the brake is one that I take some interest in. We have several engines running with the brake applied to the driving wheel, and our experience is that it is wearing the tires, and wearing them irregularly; that is, it is not wearing all four alike. I would like to hear from other members whether their experience is the same. It has been a serious question with us whether it was best to continue the use of the brake on the driving wheel because of the increased expense of the tire, although I must say that it is very effective and works very nicely; yet the question is, whether it will pay to continue the use of this brake at the expense of the tire. Our experience has been that one wheel is worn much worse than the others, so much more that we had to take the engine off and turn the tires.

Mr. YOUNG, Cleveland, Columbus, Cincinnati & Indianapolis Railroad—I applied the brake to one engine a few months ago, and my experience was not very favorable. It seemed to be wearing the tire very fast, and also wearing the brake shoes. A set of cast iron shoes would run only about two hundred and fifty miles, with the ordinary stops, before they would have to be renewed. The brake was fitted up with the cam motion of Westinghouse. There seemed to be altogether too much power when applied to the wheel. When the brake was applied the engine would jump as though she had been reversed and no brake had been applied other than through the engine. This was rather unpleasant for the passengers in the train. The expense of replacing the cast iron shoes so frequently rather hinders its use, in my estimation.

Mr. HUDSON, Rogers Locomotive Works—There is another consideration of interest in relation to brakes applied to either driving or tired wheels. If they require to be used continuously for ten or fifteen miles, the tires must be fastened so that they will not turn around or get loose, because the heat

imparted to them tends to loosen them. In cases of that kind it becomes necessary to fasten the tires in some way so that they can not be moved either laterally or turned around. In constructing some engines recently for South America, where the Westinghouse Brake was applied to the driving wheels, we found it necessary to fasten the tires so that they could not move in either direction, although they might get loose. I apprehend that that is one of the things to be guarded against in the use of this brake.

Mr. Robinson, Great Western of Canada—I might say that the driver who ran this passenger engine of which I spoke, asked me to allow him to have a stop cock put on, so that he could use the train brake independent of the driver brake. His idea is that it is too powerful to use all at once, and he would rather use the train brake by itself, and the driver brake only in cases of emergency, so as to bring the train to a full stop after the first shock has been taken off the train. That shows the power of the brake.

On motion of Mr. McAllister the discussion on this report was closed.

The President—The next business in order is the report on "Lubricants for Locomotives," but the Committee is not quite ready to report. I would state to the Convention that there has been no report made on Boiler Explosions. Two Committees were appointed last year, of which I was the Chairman, to attend experiments to be made by the Government, but there have been no experiments made this year, and consequently there is no report to be made. It is, however, thought that there will be some experiments made during the coming year; and it might, perhaps, be well to have the Committee continued, or some other Committee appointed for the ensuing year.

On motion, the Committee was continued.

The President—The Secretary will now read the report of Committee on Narrow and Broad Gauge Rolling Stock. The Committee consists of Messrs. Hudson, Sprague, and Brooks.

Report of Committee on Narrow and Broad Gauge Rolling Stock.

To the American Railway Master Mechanics' Association:

Gentlemen—The Committee appointed at the last meeting of the Association, on the subject of Narrow and Broad Gauge Rolling Stock, beg leave to submit the following report:

The questions asked were as follows:

1. What is the gauge of your road?

2. What and how long are the maximum grades on your road?

3. What is the minimum radius of the curves, and how long and frequent are they on your road?

4. Give size, weight (including tender), and tractive power of

each class of engine on your road. Let the tractive power be determined from work done.

5. Give weights of each class of cars (four and eight wheeled), nd the loads carried by each.

6. What is the relative proportion of income from your passenger nd freight traffic?

7. In what does the bulk of your freight traffic consist?

8. Give cost of repairs of engines and cars per mile.

9. From your experience, which is the best gauge—narrow or dinary (four feet eight and one-half inches)?

Replies were received from twelve roads, and the information obned is embodied in the accompanying table.

Very full reports were made by Mr. Peddle, of the St. Louis, ndalia, Terre Haute & Indianapolis Railroad, and Mr. Wells, of Jeffersonville, Madison & Indianapolis Railroad.

To the ninth question Mr. Peddle replied as follows:

From my experience I would prefer the five feet gauge to either the other gauges. For two reasons: the first is, that a wider eel-base would enable the modern raised deck coaches and sleep- cars, in which the center of gravity is much higher than the old le coaches, to be run with greater steadiness and freedom from illation at high speeds. Another reason is, that it would give omotive builders more room between the frames, and enable them ower the barrel of the boiler, and also widen the fire box, and do y with the offset in the sides, in the vicinity of the tubes—a y objectionable feature—and make them straight or narrower at top.

The information in relation to narrow gauges (viz., less than feet eight and one-half inches) is too meager to make a fair parison between them and the ordinary gauge.

From the table it will be seen that five prefer four feet eight and half inches, or five feet to the narrow gauge or gauges.

Two prefer gauges of three feet.

WILLIAM S. HUDSON,
H. G. BROOKS,
H. N. SPRAGUE,
Committee.

motion, the report was received.

E PRESIDENT—If there is no discussion on the subject of this report,

the Secretary will read the next, which is the report of the Committee on Machinery for Supplying Water to Tanks. The Committee consists of Messrs. White, Flynn, and Fry.

Report of Committee on Water Supply.

GENTLEMEN—Your Committee, appointed at last Annual Meeting of the Master Mechanics' Association, to continue their investigations on the subject of Machinery for Supplying Water to Tanks, giving description of engine, windmill, or device, with cost of working same, regret to state, at the outset, that very little additional information has been communicated to them during the past year, only ten Master Mechanics responding to circular—a majority of whom either gave no new light on the subject, or merely referred us to last year's letters as containing their views and experience. As a consequence we are unable to improve upon our last report to any great extent, or do that justice to the subject which it deserves, and which the interests of the Association demands.

The following is a copy of circular which was forwarded to members of the Association:

To ——— ————, *M*——— *M*———:

DEAR SIR—The undersigned, a Committee re-appointed at the last Annual Convention of the American Railway Master Mechanics Association, to report upon the subject of "Machinery for Supplying Water to Tanks, Giving Description of Engine, Windmill or Device, with Cost of Working the Same," beg leave to call your attention to the following questions, and solicit an early reply to the same:

1. What arrangements have you for supplying water to tanks at water stations on the line of your road?

2. Please give description of engine, steam pump, windmill, horse power, or other device, employed for the purpose, the number of gallons raised per day, or for each twenty-four hours, and the cost of working the same; or, if the tanks are supplied by a natural fall, describe the kind of pipes used to convey the water, and the best method of putting them down; the kind of bulkhead or dam at the fountain, and best method of keeping the strainer from being choked up or damaged from driftwood, etc.; also describe the means of protection you have found most effectual in frosty weather for pipes

under ground or otherwise situated, and for tanks in open air and machinery in buildings.

3. Describe what arrangements you have for delivering water from tanks to the tenders, and state whether it can be practicably kept free from leakage and safe during frosty weather.

4. Describe the best method you are familiar with for supplying water to tanks.

5. In your description, give, as far as convenient, drawings or sketches of the parts you describe; and, where practicable, statements of the cost of the work.

6. The Committee are desirous that the importance of giving the *cost* of raising the water, and the number of feet raised, may not be overlooked as a satisfactory report can not be made without it.

Respectfully yours,

J. L. WHITE, *E. & C. R. R.*,
J. H. FLYNN, *W. & A. R. R.*, } *Committee.*
HOWARD FRY, *Erie R. R.*

In reply to circular we herewith give a summary of all information received during the past two years.

In supplying water to tanks the following methods are mentioned, viz.: Pump worked by steam and Caloric Engine, Pulsometers, Natural Fall or Gravitation, Windmills, City Water-works, Horse and Hand Power, Hydrostatic Rams, and Water-wheels.

STEAM POWER.

Under this head are mentioned steam engines with cylinders eight by sixteen, four and a half by twelve, and four by six inches; also steam pumps of various manufactures, among them the Blake, McGowan, Knowles, Worthington Duplex, Moor & Co., Cope & Maxwell's, as also the Pulsometer. The number of gallons raised by different pumps, which, of course, varied according to their capacity and the requirements of service on different roads, is given in a few instances, but the cost of raising same is generally omitted, or some important item overlooked which prevents a comparison. Several Master Mechanics report that pumps are attended to or worked by cleaners, watchmen, and persons employed at stations in other capacities, and the steam power frequently applied to other purposes, such as sawing wood, warming stations, or running machinery, rendering

it somewhat difficult to arrive at actual cost. The following are the answers received to question No. 2 of circular relative to cost of supplying water to tanks:

Mr. Peddle states that on the T. H. & I. Railroad with No. 6 Knowles Pumps, it costs six and two-tenths cents to raise one thousand gallons a distance of thirty-five feet, but adds that these figures do not include interest, or original cost, or cost of repairs on pumps, it being difficult to separate these items from repairs of tanks, spouts, and buildings.

Mr. Robinson, of the Great Western Railroad, Canada, states that where steam power is used for pumping, the relative cost to quantity of water raised, is about one dollar for ten thousand gallons, fuel and wages included, the water being raised ninety feet.

Mr. Peeples, of the Central Railroad Company, of New Jersey, states that with the Worthington Duplex Steam Pump, ten-inch steam cylinder, six-inch plunger, and ten-inch stroke, one hundred and fifty thousand gallons can be raised in ten hours at a cost of $85 per month.

Mr. Hayes, of the Flint & Pere Marquette Railroad, says that with the Knowles Patent Steam Pumps it costs two dollars to fill a tank containing eight thousand gallons, the raise of water being thirty-one feet.

Mr. Ross, of the M. & C. Railroad, states that with Cope & Maxwell's new improved pumping engines, thirty-six thousand gallons is pumped in twenty-four hours at a cost per day, labor and fuel, of $1.75.

Mr. Finlay, of the Cairo & Fulton Railroad, Arkansas, gives the cost of filling tank containing sixteen thousand nine hundred and twenty gallons at $57 per month, average lift of water being eighteen feet. The pumps used are the four by eight McGowan & Knowles No. 5 Steam Pumps.

Mr. Wells, of the J., M. & I. Railroad, while unable to give the number of gallons raised, with cost of same, gives the cost per month of water supply for main line and branches (two hundred and twenty-four miles in all), at $600, and repairs of stations, pumps and fixtures, fuel, and all other expenses, at an average of $385 per month. At one station on this line water is supplied by portable engines belonging to private parties, at a cost of $40 per month.

NATURAL FALL OR GRAVITATION.

Where tanks are supplied by natural fall or gravitation, descriptions have been given as follows: The pipes used for conducting water are from two to three and one-half inches in diameter. In one instance mention is made of water being conducted a distance of four thousand five hundred feet through old boiler tubes two inches in diameter, the connections being made with cast-iron couplings, with fine thread on pipe. In the larger size of pipes the joints are made with lead as for city water-works pipe. The head of fountain or spring is usually inclosed with masonry, over which a house is built to protect strainer. Dams are also built of masonry, banked with earth, and strainers of copper or iron over end of pipe. Mention is made, in several instances, of the pipes being dipped in a solution of coal tar or asphaltum as a preventative against corrosion. Mr. Ross, of the M. & C. stating that in his department they were taken up every three years and cleaned. For protection against frost, laying the pipes a suitable distance under ground is all that is recommended, three to four feet being mentioned, varying according to location or climate. Pipes above ground are in boxes filled with earth, sawdust, ashes, or manure.

Mr. Peddle, of the T. H. & I. Railroad, states that when water is supplied by gravity from ponds, and trouble experienced from pipes filling with mud, they are blown out by attaching a small hose to the ends of the pipes at water stations, and also to the heater-cock of a locomotive; or, what is still better, to the reservoir of the Westinghouse Brake, and using the air pump to drive a current of water back into the pond.

WINDMILLS.

Very little information has been communicated, under this head, further than stating that they are used successfully on different lines. Mr. Boone reports the cost of operating them on the P., Ft. W. & C. Railroad, about $10 per year, and states thas they require no attention except oiling once a day, which is done by the section foreman as he goes over his section in the morning. Larger tanks or reservoirs are required in connection with them than steam pumps, as provision must be made for a supply in case the wind should fail

and an automatic arrangement stopping the mill when the tubs are full. As for other systems mentioned, all that can be gleaned from the replies is as follows: Mr. White, of the E. & C. Railway, states that at the terminal stations on this line, the water is supplied from city water-works at a cost of twelve and three-tenths cents per one thousand gallons, and at intermediate points by pumps worked by horse power at a cost of fourteen and one-half cents per one thousand gallons, the average lift of water being twenty-five feet.

Mr. Peddle, of the T. H. & I. Railroad, gives the cost of raising water a distance of thirty-five feet, with horse power, at twenty-two cents per one thousand gallons; pumps four inches diameter and eight-inch stroke.

Mr. King of the C., C. & A. Railroad, South Carolina, states that the best and most economical arrangement for supplying water to tanks on that road is the water wheel, which, after being once put in operation, costs little or nothing for repairs. He incloses sketch and detailed cost of same, which, with water tank, amounts to $630. On this line hand pumps are operated by colored men at a cost of $18 per month.

Mr. Weaver, of the Eastern Kentucky Railroad, states that the pulsimeter works very nicely where water does not have to be raised over fifteen feet, beyond which they do not answer so well. They are very reliable, and the cost of operating is trifling.

Mr. Fuller, of the A. & G. W., says that with twenty pounds of steam they raise one hundred and seventy-five gallons per minute.

ARRANGEMENTS FOR DELIVERING WATER FROM TANKS TO TENDERS.

The arrangements mentioned for delivering water from tanks to tenders are for stations near the track, the common drop pipe, and where water is brought from a distance, the revolving stand pipe. The descriptions given by Master Mechanics of the construction and operation of delivery pipes vary somewhat in details, but in the main they are constructed on the same general principles, and have been omitted from report by Committee as they did not wish to burden it with details already familiar to members. Several Master Machinists report using patent drop and stand pipes, which give good satisfaction, among them McGowan's, Linn's, Halliday's, and Morgan's. Opin-

ions as to the best method of supplying water to tanks have been given as follows:

Mr. Robinson, of Great Western Railroad, Canada, states that the windmill is, undoubtedly, the most economical, provided the capacity of tank is sufficient and locality favorable for a reliable water supply.

Mr. Boone, of the P., Ft. W. & C. Railroad, considers natural fall or gravity the best, when it can be had; next, windmills, where the formation of the country will admit; and, next, steam power.

Mr. Ross, of the M. & C. Railroad, considers the fountain reservoir or natural fall the best and cheapest mode where the water supply is fully ample; the water to be conducted through large cast-iron pipes, and then discharged directly into engine tender by means of the McGowan or Morgan improved water cranes.

Mr. Peddle, of the T. H. & I. Railroad, considers natural fall or gravity the most economical, but has found it unreliable in case of drought, and considers steam pumps the most reliable.

Mr. Fuller, of the A. & G. W. Railroad, considers gravity the best method where it can be got at, and the next best thing the Pulsometer.

Mr. Sedgley, of the L. S. & M. S. Railroad, gives the preference to a good, efficient steam pump.

Drawings have been received from the following Master Mechanics:

From Mr. Robinson, of the G. W. Railroad, Canada, drawing of twenty-four feet Water Tank or Air-tight Vat, constructed on Burnham's patent, in which the construction and operation of tank valve and drop pipe is very clearly set forth.

From Mr. Thompson, of the Eastern Railroad, Massachusetts, Revolving Stand Pipe for delivering water to tenders.

From Mr. Peeples, of the Central Railroad Company, of New Jersey, Tank Valve and Drop Pipe for water stations.

From Mr. Ross, of the M. & C. Railroad, drawings descriptive of Water Tank Valve and Drop Pipe, as also two designs of Tank Houses on the line of this road.

From Mr. King, of the C., C. & A. Railroad, South Carolina, drawing of Water Tank, Water Wheel, and Tank Valve.

The foregoing embodies the statements and views of the different

Master Mechanics who have responded to circular, and is presented by your Committee as the substance of all information received on the subject of water stations during the past two years. In view of the limited number of answers received, and in a majority of cases the meager and incomplete nature of the information communicated, especially as regards the cost of supplying water to tanks, sufficient data has not been furnished to enable us to institute a just comparison as to the relative merits of the systems mentioned.

The cost per one thousand gallons of raising water with steam pumps, and number of feet raised, has been given only in a few instances, which we mention as follows:

6 2-10 cents per 1,000 gallons, raised 35 feet.
10 cents per 1,000 gallons, raised 90 feet.
25 cents per 1,000 gallons, raised 31 feet.

Two Master Mechanics have given the cost of raising water by horse power as follows:

22 cents per 1,000 gallons, raised 35 feet.
14½ cents per 1,000 gallons, raised 25 feet.

One Master Mechanic gives the cost per one thousand gallons of water, supplied from city water-works, at twelve and three-tenths cents.

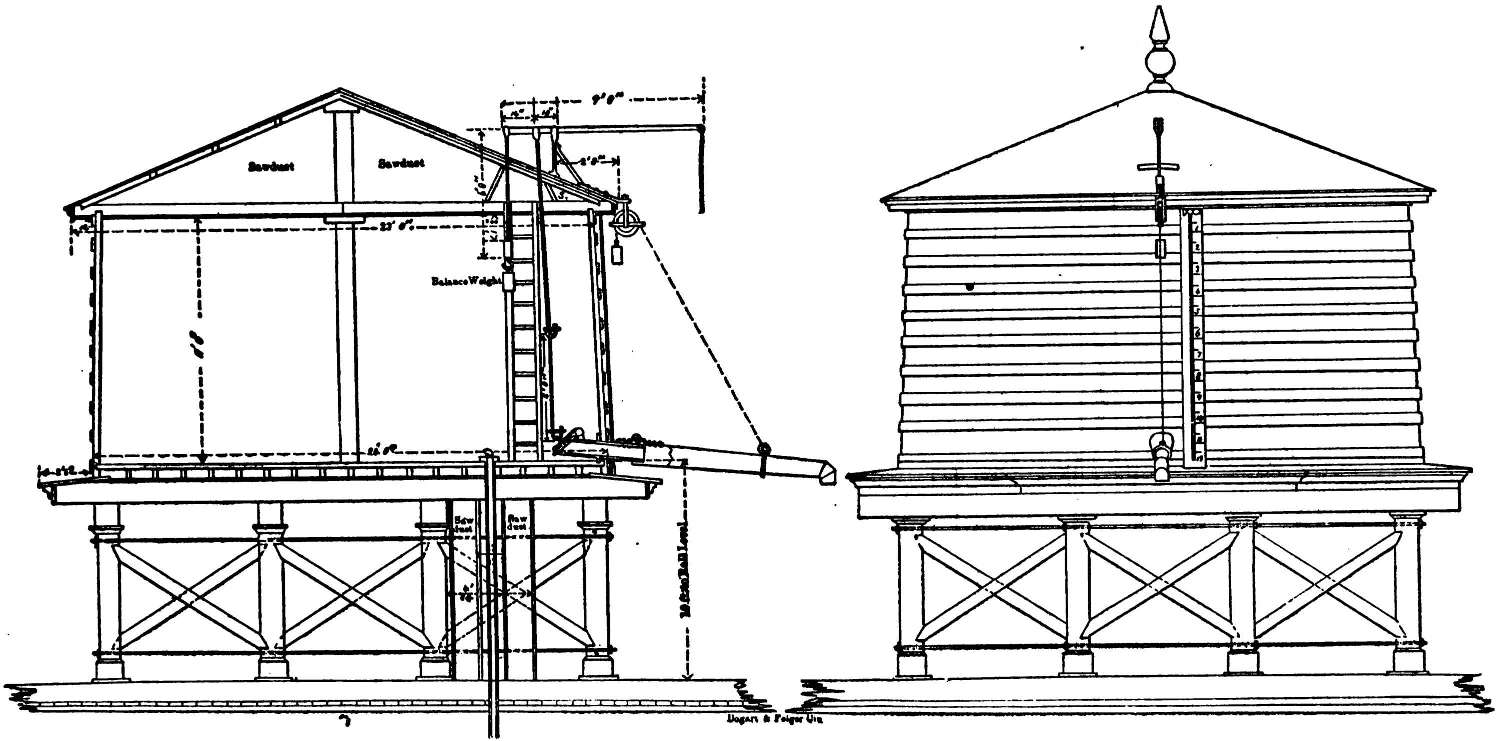
Where water is supplied by gravity or windmills very little, if any, expense further than first cost, is mentioned. Favorable mention is made by several Master Mechanics of the pulsimeter, a late invention operating with great economy and certainty, which, should it fulfill the claims or expectations of its inventor, promises to supersede many of the methods now in use for supplying water to tanks.

In conclusion, your Committee, not deeming the information received of a nature which would enable them to present a satisfactory report, respectfully refer the subject to the Convention for discussion, hoping that facts and figures may be elicited from members personally, which we have not been able to obtain heretofore.

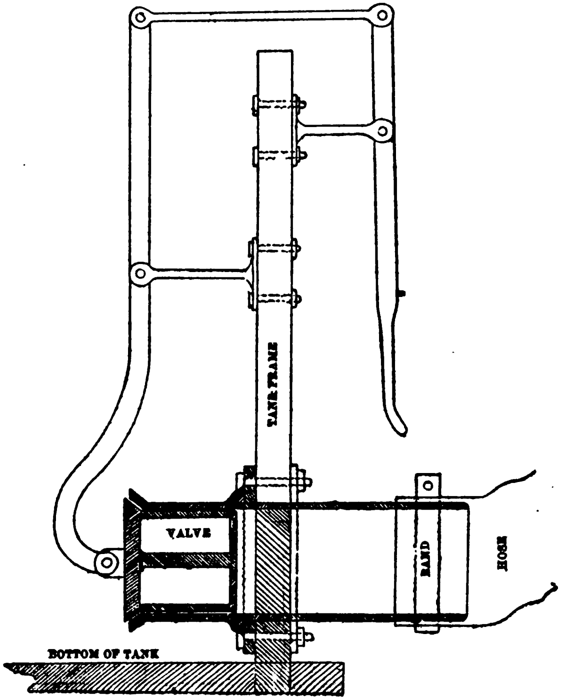
Respectfully submitted,

JOHN L. WHITE,
J. H. FLYNN,
HOWARD FRY,
} *Committee.*

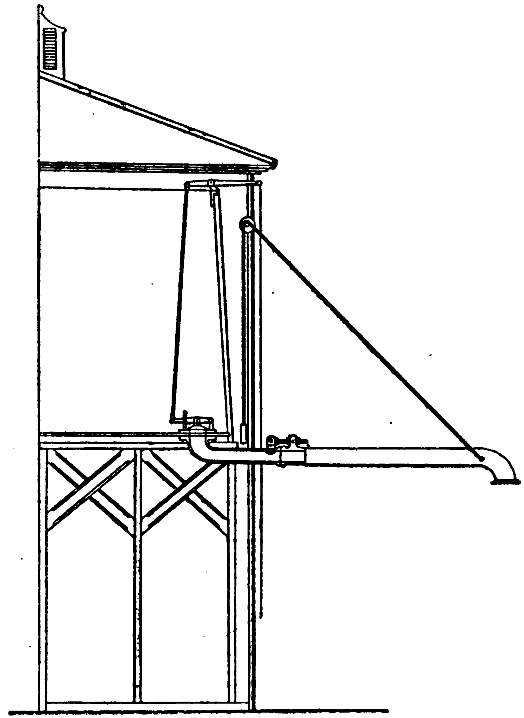
TWENTY-FOUR FOOT TANK FOR WATER SERVICE—Great Western Railway of Canada. Scale ½ Inch—1 Foot.



Tank Pipe and Drop Valve.

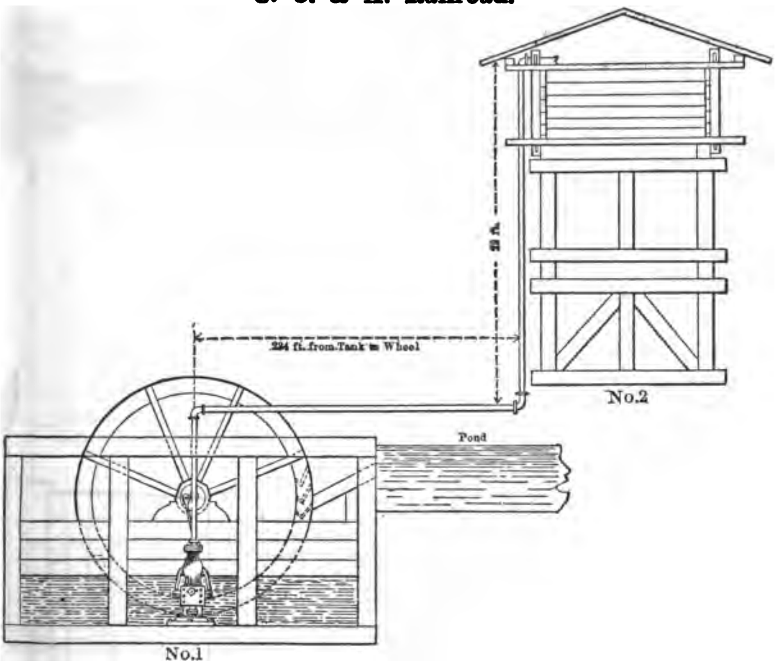


Tank Valve and Pipe for Water Station.—T. W. Peeples, M. E.



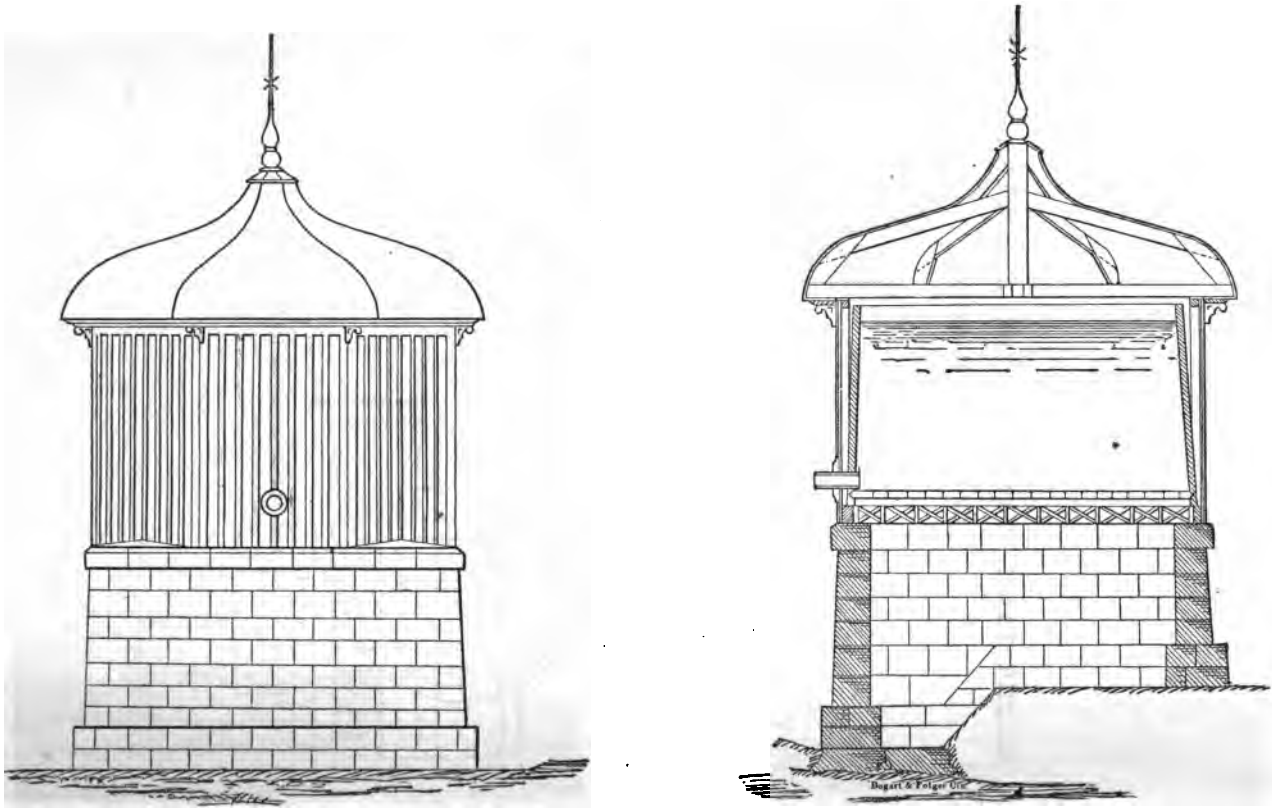
WATER TANK, WATER WHEEL, AND TANK VALVE.

C. C. & A. Railroad.

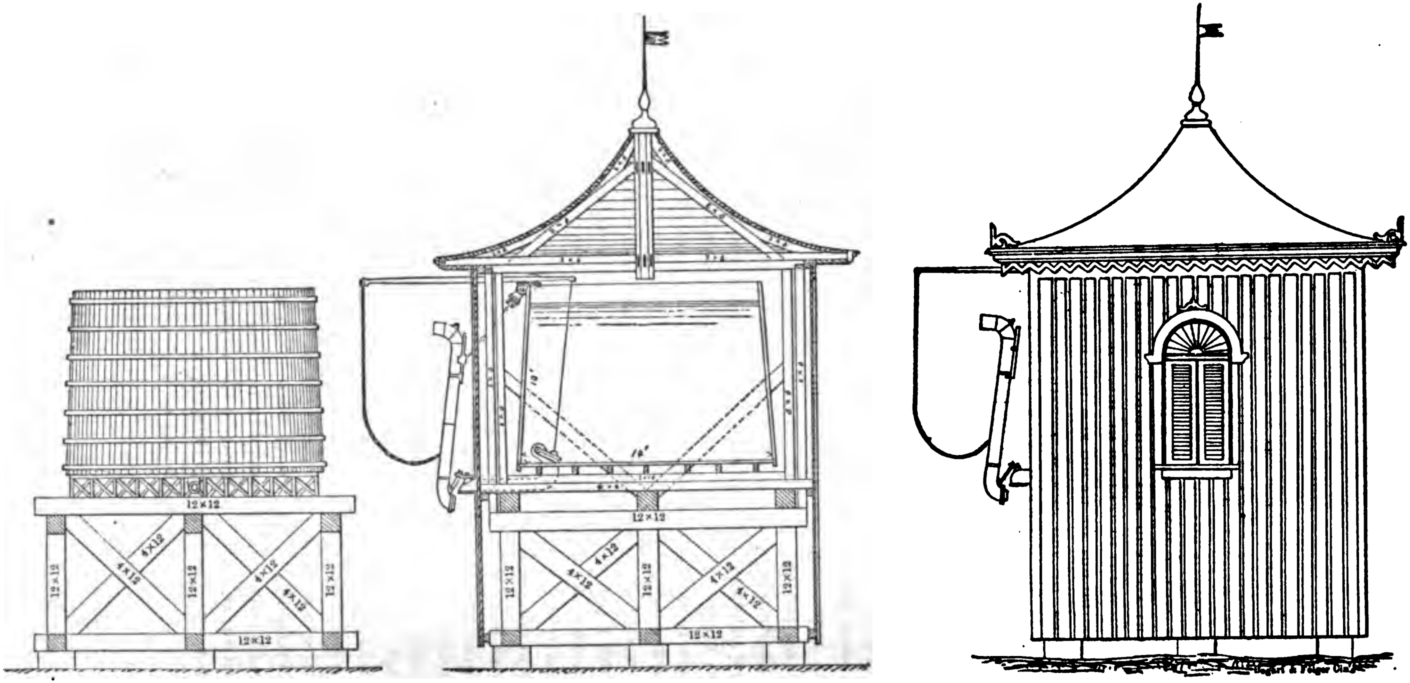


Scale ½ Inch to the Foot for No. 1 only.

WATER TANK AT SCOTTSBORO', ALA.--M. & C. RAILWAY.—Scale ¼ Inch—1 Foot.



WATER TANK AT MEMPHIS—M. & C. Railway. Scale ¼ Inch—1 Foot.



On motion, the report was accepted.

THE PRESIDENT—Is there any discussion on this subject?

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—As some reference has been made in that report to an instrument known as the pulsimeter, I will state my experience with an appliance of that kind a year ago last summer. It was called a condensing pump, but, if I understand the pulsimeter, it was the same thing in principle. The principle is that the steam is let into a cylinder, and then it is condensed, and that raises the water in the cylinder until it becomes full, or nearly so, and then the steam is let in on top of that cylinder; slowly the valve below closes, and the pressure of the steam on the top of the water forces the water up to the height desired. While this cylinder is being emptied of its water, the one immediately along side of it is being filled from the vacuum pump by condensation of the steam. An acquaintance of mine applied to me for an opinion as to the value of that appliance, and I gave him rather an adverse opinion of it, and then he insisted that I should try an experiment with it and test it with the ordinary pump to ascertain what the value of it was, so far as economy was concerned, in the expense of raising water in that way. I had a small vertical engine and boiler at a station where we had some time previous used it for pumping water with one of those old-fashioned double-cylinder pumps. Each cylinder was a single-acting pump. It had been out of use for some time from the fact that we were then receiving our water supply from the city water works. He brought his pulsimeter, as I will call it, attached it to that boiler, put the pipe down in the same well from which this pump ordinarily took its supply, and ran his pipe up into the top of the tub, delivering the water into the same place as the other pump had done. The boiler was fired up, and we took a barrel of water, filled full, attached a small hose to the bottom of the barrel, and from it supplied the pump which supplied this boiler. He ran his pulsimeter, and used steam from that boiler until this barrel was consumed by the boiler. Then the depth of water put into the tub was carefully noted. He made three different tests with his machine, each time using a barrel of water. Then the engine was attached to this old-fashioned pump by a belt, and another barrel of water was used. The engine drove the old pump until that barrel of water was used up, and that barrel of water by the use of the old-fashioned pump put in precisely double the quantity of water into the tub that was put in by the pulsimeter. The quantity that he put in was arrived at from an average of three different tests, and the three tests averaged precisely one-half the quantity that was put in by the old-fashioned pump. It required a great deal of care in regulating his condensing pump to prevent condensation of the steam. If the steam was allowed to flow in rapidly at the top, a large proportion of it was condensed, and it was, therefore, necessary to allow it to go in slowly and carefully, so as not to force the steam down into the water, but to retain a

layer of air between the water and the steam. If this care was preserved it could, on an average, put in one-half as much as an ordinary pump. If any member of the Association has had any experience with this pulsimeter, or with an instrument of that kind, or have had them tested in any way, I would like to know whether their experience corresponds with mine.

Mr. WHITE, Evansville & Crawfordsville Railroad—I do not know, from any actual experience, any thing about the pulsimeter, but I would like to ask Mr. Wells which of the two took the most steam; or, how much more steam was applied to the pump than to the pulsimeter? My opinion has been, from what information I could gain, that the pulsimeter would do more work with the same quantity of steam.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—I would state that this barrel of water that was evaporated through the pulsimeter, indicated precisely how much steam was used. When a barrel of water was evaporated and went through that condensing pump, it put only one-half the quantity of water into the tub that it did in working the barrel of water through the steam cylinder which drove the pump with a belt. There was a barrel of water used in each case; three different tests were made with the condensing pump, and but one test made with the other. The result was that the condensing pump put in only fifty per cent. of the amount of water that could be put in by the use of the other pump.

On motion of Mr. Chapman the discussion of this subject was closed.

THE PRESIDENT—The next business is the report of your Committee on Mechanical Laboratory. The Committee consists of Messrs. Robinson, Wells, Boone, Chapman, and myself. The report is in the hands of the Secretary.

Mr. FLYNN, Western & Atlantic Railroad—As the reading of that report would occupy considerable time, and it is now quite late, and there seems no necessity for our continuing longer in session to-day, I would move that we adjourn until to-morrow at nine o'clock.

Carried.

THE PRESIDENT—Before adjourning let me say that I hope every member will be here promptly at nine in the morning, so that we can commence business early. We still have several reports to read, and on some of them there will probably be discussion.

The Convention then adjourned until Thursday morning at nine o'clock.

THIRD DAY'S PROCEEDINGS.

The Convention assembled pursuant to adjournment, Thursday, May 13th, at nine o'clock A.M.

THE PRESIDENT—The first business in order is the report of the Committee on Lubricants for Locomotives. The Committee consists of Messrs. Miles, Garrett, and Garfield. The report is in the hands of the Secretary.

Report of Committee on Lubricants for Locomotives.

To the American Railway Master Mechanics' Association:

GENTLEMEN—Your Committee upon "Lubricants for Locomotives" has exerted itself during the past year to obtain some useful information regarding the subject it was appointed to investigate.

A carefully considered circular was distributed with the expectation of collecting actual data from the records of the different roads, which data, when arranged in convenient tabular form, would furnish a ready and interesting comparison of the merits of various lubricants, as well as of roads using them.

The economical result of any lubricant in practice depends on many other things besides its own intrinsic merit. The weight of engines, the character of the water, fuel, ballast, dust, state of the track, grades, the condition in which the machinery is kept, and above all the care exercised by the men in charge—all these things affect this result very seriously.

Your Committee, therefore, bearing these things in mind, attempted, in framing the questions of their circular, to take cognizance of all these varying conditions, hoping that by this means the table might show the data for the lubricant along with the conditions which influence its economical result, and thus prove to be of some real service. It was thought that such a table, made up from actual experience, would add its quoto of value to the report of the Association.

The subject, however, is a slippery one, and the Master Mechanics have shown themselves equally slippery. Only twenty have responded to the circular. Pains have been taken to write to the delinquents, but in most cases without avail, while, partly from want

of more definite questions, the replies received do not in many cases give all the required conditions.

Your Committee can, therefore, lay before you the results of the experience of twenty roads during the past year, condensed in tabular form as proposed, from which some deductions can be drawn and comparisons made, which will doubtless prove interesting and perhaps instructive.

We find that fifteen Master Mechanics out of the twenty use tallow exclusively as a lubricant for valves and cylinders. Several, who are fortunate enough to get pure rendered tallow, report an exceedingly high duty.

The Illinois Central gives one hundred and five miles run per quart, the Vandalia one hundred and nine, and the Texas Pacific one hundred and seventeen miles run per quart (average), for valves and cylinders with tallow lubricant. The manufactured tallow, however, is apt to be bleached with chemicals and adulterated, or fermented and acid, forming stearic acid, which corrodes and eats away the iron and gums up the working parts.

Mr. King, of the Charlotte, Columbia & Augusta Road, suggests that some iron may resist this more than others, and mentions one engine on his road using the same tallow, same water, and all other conditions equal, yet which never corrodes or gums up.

Mr. Robinson, of the Great Western of Canada, reports that, although he gets a higher duty from lard oil and from cylinder oil, the commercial advantage rests, nevertheless, with tallow, as it is with them cheaper than any of the others.

The general verdict is in favor of pure tallow, if it can be had; but, if not, then good lard oil.

Twelve Master Mechanics out of the twenty report as feeding by cab tube in preference to automatic cups. Five prefer the Dreyfus cup, which acts by displacement on the principle introduced by Mr. Ramsbottom.

The highest duties are given by the cab tube, and they occur, as might be expected, on the level roads where no long distances are run without steam. Mr. Reuben Wells, of the Jeffersonville, Madison & Indianapolis Railroad, states that the automatic cups use the most lubricant, but that they enable the valves to be run longer

without refacing, and also that too much economy in lubrication is not the best for the machinery.

The cups, however, which act by displacement do not work well where long distances are run without steam, as they are then deprived of the very steam which works them by means of its condensation.

General preference inclines to the cab tube. The lowest duty given for *cylinder and valves* is fifty-six miles run per quart on the Delaware, Lackawanna & Western Railroad.

For guides and journals petroleum seems to be generally adopted, either *alone* or mixed with lard oil, fish oil, or tallow oil. While it is admitted that good sperm oil or lard oil would probably be a more perfect lubricant for guides and journals, yet in practice, owing to the greater cheapness of petroleum and the convenience and facility with which the others can be *tempered* by admixture with it, the commercial or economical advantage rests with petroleum or natural oil and its various mixtures. The West Virginia natural oil is the one most frequently referred to as excelling in lubricating qualities.

Self-feeding cups are the rule and give the highest duty. Many are very decided in their preference for the Dreyfus rotary spindle cups.

A comparison between the Central of New Jersey, gauge four feet eight and a half inches, using throughout a manufactured oil (some mixture, doubtless, of petroleum), and the Delaware, Lackawanna & Western, six feet gauge, using tallow for cylinders and valves and petroleum alone for guides and journals, shows in each case twenty-seven miles run per quart, counting *total* lubrication. These two roads intersect the same or similar regions, have similar grades and all other conditions except the difference of *gauge*.

A comparison of results of *total* lubrication, as seen in the annexed table, shows the lowest duty to be given by roads with long grades where considerable distances are run without steam; also where much dust prevails, and fine sand or grit from fuel or ballast. The dust seems to be worse than the grades as the Philadelphia, Wilmington & Baltimore Railroad gives the lowest duty of all, viz., twenty-two miles run per quart; next lowest, Delaware, Lackawanna & Western and Central of New Jersey twenty-seven.

The highest duties are given by the level roads, as the Vandalia, Texas Pacific, and Jeffersonville, Madison & Indianapolis Railroads. Mr. Reuben Wells, of the Jeffersonville, Madison & Indianapolis Railroad, has given us some data since the table was made up which shows an extraordinary duty, as follows:

Average for March, 1875.—Five passenger engines, one hundred and twenty-four miles run per quart of tallow for cylinders and valves; seventy-six miles run per quart for guides and journals, West Virginia natural oil, which gives fifty miles run per quart for *total* lubrication, the highest average your Committee has received.

Also eight freight engines, March, 1875.—Eighty-seven miles run per quart of tallow for cylinders and valves; sixty-two miles run per quart for guides and journals, West Virginia natural oil, which gives thirty-seven and one-fourth miles run per quart for *total* lubrication.

In comparing results per annexed table some error may creep in from the different ways of computing mileage of trains, some roads allowing a percentage on freight trains for switching, and others merely allowing the length of road exact.

In one or two cases your Committee is not quite certain that the oil for tenders has been included; and *one*, the Jeffersonville, Madison & Indianapolis Railroad, states that oil for the cab lamps is included in the quantity given in the table. This should be kept separate, if possible, in the future.

Two of the reports have included the head-light oil, which, therefore, was entered in a special column, and could not be compared with other roads at all.

NEW SYSTEMS AND NEW LUBRICANTS.

Mr. Rushton, of the Atlanta & West Point Railroad, Georgia, reports a trial of the Brosius system on car trucks. It consists of a wooden saddle covered with cotton web held up by springs against under side of journal, in the oil cellar of journal box. The cotton web acts as a wick. The result he gives as eleven hundred and twenty-five miles run per quart of West Virginia natural oil mixed with lard oil or tallow. He has also tried for his locomotive driving boxes a roller in oil cellar, held up by springs against under

side of journals. The data for this is *slightly* indefinite, being eighty-seven miles run to two table-spoonfuls of West Virginia and lard oil. Rather a small dose! Your Committee give this experiment as received, but can give no opinion upon its merits.

Mr. Graham, of the Bloomsburg Railroad, gives record of tank box packed with plumbago and oil November 25, 1874, which, at date of his report, February 27, 1875, was still running, having made eight thousand and ninety miles without repacking.

J. A. Hanglin, of the Texas Pacific Railroad, gives result of a compound called "Polar Grease," which in car journal boxes has made a duty of twenty-six hundred miles per quart.

In conclusion your Committee would respectfully suggest that in future the circular of questions be framed in such a manner as to be in effect a blank form, which each Master Mechanic could easily fill out and *return*, thus saving the labor of writing and rewriting the questions and answers.

Very respectfully,

F. B. MILES, *Philadelphia*,
H. D. GARRETT, *Pennsylvania*,
E. GARFIELD, *Hartford, Providence & Fishkill*, } *Committee.*

On motion, the report was received.

THE PRESIDENT—Discussion on this subject is now in order.

Mr. MILES, of Philadelphia—As Chairman of that Committee I would like to state, for the information of the Association, that the Committee was promised some interesting information in regard to a system of lubricating that consists of a rotary disc fastened to the end of the axle, which, as it rotates, throws the oil on the top of the journal. It has been used on the Lehigh Valley Road for two or three years, and, as they claim, with wonderful results. The member from that road, however, failed to send the information, and it will have to go in a report at some future time, if at all.

Mr. HAYES, Illinois Central Railroad—I would suggest that this Committee be continued for another year, and that there be some system arranged in our circulars by which all the Master Mechanics may act understandingly. Some report the oil used in the head-lights, lamps, and torches, while others simply report the oil used upon the running parts of the engine. Consequently this makes a wide difference in the result of the comparisons. Upon our road we include, in the report, all the oil used on or about the engine for any and all purposes. For instance, each engineer has a torch which gives an immense blaze; this is used in running trains at night when he wants to examine or oil his engine; we have a lamp in the cab, and on our switch-

ing engines there is a light at each end of the engine; each fireman has a lamp, and on some roads they carry red lanterns for signals. All these items, and the head-light oil, are included in summing up the total amount of oil used. In the circulars it might be stated that information was required separately as to the amount of oil used for lubricating the engine, and that used for burning purposes, and the tallow or other oil used for cylinders and valves. I think if the questions in the circular were arranged in that way we might be able to make a table which would be useful to the Association.

THE PRESIDENT—If there is no action on the suggestion of Mr. Hayes, or further discussion on this subject, we will proceed with the next business, which is the report of the Committee on Standard Axles. The Committee consists of Messrs. Forney, Sellers, and Nott. Mr. Forney, the Chairman, will read the report.

Report of Committee on Standard Axles.

To the American Railway Master Mechanics' Association:

GENTLEMEN—The Committee to whom this subject was referred back at your last Annual Convention for further consideration, in order to comply with the request then made, that the reasons which induced them to make the recommendation contained in their report should be given more fully, issued the following circular of inquiry:

"At the last meeting of the American Railway Master Mechanics' Association, the subject of a standard for car and tender axles was referred back to the Committee to whom it had been submitted, with a request that the reasons should be given for the adoption of the standard form and proportions which were recommended. As a large number of axles of that kind have been put into use since then, the Committee have delayed issuing their circular to this late date, in order to get the fullest reports possible of the experience in the use of that kind of axles. They therefore present the following inquiries, which it is to be hoped will be answered *immediately*, so that the Committee may be able to present the latest accessible information relating to the important subject submitted to their consideration:

"1. What are the sizes of journals used under locomotive tenders and cars on your road?

"2. Which sizes give the least trouble from heating?

"3. If possible, report the number of axles broken during the past year on your road and the sizes of each. If it is not possible

to give the actual number of each kind broken, give your opinion formed from observation of the relative proportion of breakages of each kind.

"4. Have you observed any difference in the relative amount of power required to draw cars with axles having large as compared with those having small sized journals; if so, how did the amount of power required for the one size compare with that for the other?

"5. Have you noticed any difference in the wear of brasses and the consumption of oil on different sized journals? If so, give the Committee any data you may have, or the results of your observation."

To this circular the Committee received twenty-six answers. The replies to the first inquiry, "What are the sizes of journals used under locomotive tenders and cars on your road?" it is not thought necessary to report. To the second, "Which size gives the least trouble from heating?" fifteen of those who answered the circular do not report any difference; nine say that the largest journals they use give the least trouble, one in doubt, and one says that owing to the construction of the boxes with the small journal, they give less trouble than the larger ones. In reply to this inquiry, Mr. Wells of the Jeffersonville, Madison & Indianapolis Railroad says:

"The standard size of car axles adopted by this company in 1852, had three and a quarter by five and three-quarter inch journals, and at present about thirty per cent. of the cars have under them journals of that size. The balance have the standard size, three and a half by seven inches adopted in 1865. The latter gives much less trouble from heating than the old and smaller size of journal. This was demonstrated in the case of two large baggage, mail, and express cars on this road having six-wheeled trucks under them, with three and a quarter by five and three-quarter inch journals. The cars when empty weighed forty-five thousand eight hundred pounds. When they were heavily loaded and on fast trains more or less trouble was experienced with hot boxes. After several years use the trucks were rebuilt, and axles with three and a half by seven inch journals put under them. Since that time (three years ago), such a thing as a hot box under them has scarcely been known. The same can be said also of freight cars hauling heavy loads, and

the difference in this particular in our experience has been quite marked."

To the third inquiry, about the number and proportion of broken axles, the replies are, most of them, so indefinite that it has been impossible for the Committee to gain the information which they hoped to elicit by this question. Five of the circulars received contain no reply to this inquiry; five report that they have had no broken axles during the past year, and the balance report sixty-two broken axles during the year.

To the fourth inquiry, "Have you observed any difference in the relative amount of power required to draw cars with axles having large as compared with those having small sized journals?" twelve of the circulars contain no answers, twelve have noticed no difference, and two report that cars with large journals require more power to draw them. One of the latter is of opinion, however, that it may, perhaps, be attributed to other causes and not to the size of the journal.

Mr. Charles R. Peddle says he has not observed any difference, "but from some experiments made to test the relative friction of different sized journals, in a rude machine improvised for the purpose, I am convinced that the usually received opinions in regard to axle friction can not be correct. I apprehend that in starting from a state of rest and at very slow speed, say one to ten revolutions per minute, that the resistance of journals is in proportion to diameter, but that at higher speeds and with ample lubrication there is no appreciable difference, and also that the friction of journals within the range of dimensions used for car axles and under ordinary loads, diminishes to a very small amount at high speed; and that the increased leverage of resistance of large journals is compensated by the diminished friction consequent upon the increased velocity of the surface. I doubt if this will hold true of badly lubricated surfaces, and I also think that more frequent lubrications may be necessary with larger journals, but am not certain about that. The subject is one concerning which some careful experiments are needed as we are, I think, all afloat as to the proper understanding of the laws of friction as applied to axles."

Mr. George Richards, of the Boston & Providence Railroad, says:

"Have noticed no difference, if any, it is in favor of the Master Car Builders' Standard Axle."

Mr. Jacob Johann, of the Toledo, Wabash & Western Railway, says: "Am not prepared to say, not having made any experiments. I am of the opinion that within a limit of journal size, the load and other circumstances being equal, the large journals will 'draw' as freely and require no more power than the small ones, and they wear decidedly *better* and *longer*."

Mr. J. W. Philbrick, of the Maine Central Railroad, says: "We draw freight cars having large journals of other roads over our road. These are the cars that give us the most trouble on account of drawing hard and hot boxes. We think we can draw one-fourth more Maine Central cars than of those referred to. We say the reason is because of want of oiling on the part of the company that sends such cars, and because of the bad quality of the brasses used, and not on account of the size of the journals. Possibly smaller journals would not serve as well as the large ones under like treatment."

Mr. William H. Ellis, of the Catawissa & Williamsport Branch of the Philadelphia & Reading Railroad, says: "The cars with axles having three and three-quarters by eight inch journals, require more power to move them than the smaller sizes. We have a grade thirty-five miles long, of thirty-six feet to the mile, and we find that it requires as much power to move sixteen loaded freight cars with three and three-quarters by eight inch journals as it does to move eighteen similar cars with three and a quarter by five and a half inch journals."

To the fifth inquiry, "Have you noticed any difference in the wear of brasses and the consumption of oil in different sized journals?" eleven of the circulars named contain no answer; five say, have no information; the remaining replies to this inquiry are as follows:

Mr. J. M. Boon, of the Pittsburgh, Fort Wayne, & Chicago Railway, says: "Last year, I was inclined to favor a short journal (five and a half inches long). Am now satisfied that I was wrong, and am in favor of a journal of seven inches for all kinds of rolling stock, believing that better results can be obtained. I do not think there would be any saving in oil or any more used than in a five and a half inch journal, but believe a seven inch journal will give better

results in the wear of brass bearings than the short one with the same amount of oil."

Mr. Johann says: "From observations in the running of large journals, I notice that the large brasses endure more wear and *consume less oil* than the small ones." Mr. Ellis: "The wear of brasses is about six per cent. in favor of the three and one-fourth by eight inch journals." Mr. William Turreff, of the Cleveland, Tuscarawa & Wheeling Railway, says: "The wearing of brasses and the saving of oil is very large in favor of the large journals." Mr. W. A. Robinson, of the Great Western of Canada, says: "Our observations tend to show that the largest six by three and one-half inch journals require less oil and give better results than those of five and one eighth by three and three-sixteenth inches." Mr. John Hewitt, of the Atlantic & Pacific, says: "From general observations I am satisfied that large journals give better results in use of oil and wear of brasses than small ones."

The Committee have endeavored to give, as fully and as accurately as the space and time at their disposal would permit, the substance of the replies which they have received to their inquiries. These have confirmed your Committee in the views which they held last year, and which were embodied in the recommendation made in their report at that time. They believe that, in the consideration of this subject, it is unnecessary to dwell on the importance of having some common standard for car and locomotive tender axles. The experience of every member, it is thought, has long since taught him the importance and value of uniformity in rolling stock, especially of those parts which most frequently require renewal. Before such a system of uniformity can be adopted for all the parts of car and tender trucks, a standard for the form and dimensions of axles must be established. After this is done it will be comparatively easy to adopt a standard for bearings, oil boxes, pedestals, etc. The question which presents itself for your consideration is, therefore, simply that of the dimensions which shall be adopted for such a standard axle; and as nearly all the other proportions are dependent upon the size of the journal, the question is narrowed down to that of the length and diameter of the journal. As a kindred Association has already recommended a standard for the form and dimensions of axles, the question for your consideration, as indicated by the cur-

rent discussion of the subject, is really whether the dimensions, three and three-fourths by seven inches, of the standard axle journal, which has been recommended, is too large or not.

That friction, within very wide limits, is independent of the area of the surfaces in contact, is such a well established principle that your Committee do not think it necessary to give it any further consideration here. It is also very well known that with excessive pressures per square inch of area, that lubricants are pressed out from between the surfaces of a journal and its bearings, and then instead of being entirely separated by a filament of oil, as they should be when perfectly lubricated, they come in contact with each other, and instead of floating as it were on the lubricant, as they should if perfectly lubricated, the metal of the bearing comes in contact with that of the journal, and lubrication is then either very imperfect or may be entirely destroyed and abrasion of the surfaces occurs. It has been found by experiment that the co-efficient of friction with perfectly oiled journals is only about one-sixth that of journals very imperfectly lubricated. Of course, between perfect lubrication and that which is very imperfect there is every degree of frictional resistance. The amount of pressure per square inch of area of journal-bearing which will admit of perfect lubrication varies of course with the attending circumstances. Thus, a journal running at high speeds is more difficult to keep well lubricated than one with the same load on it running more slowly. Some kinds of grease and oil are retained between bearings better than others.

The same is true of metals. Brass and various other compounds retain the lubricant on their surface better than most pure metals. Very much also depends upon the attention given to journals and the appliances used for feeding the oil to them. Thus the bearings of the main connecting rod of a locomotive have at times a pressure of from two thousand to three thousand pounds per square inch, whereas the pressure on the journals of cars rarely exceeds one-tenth of that. In order to keep the crank pins lubricated, it is necessary to give them the most constant and intelligent attention, to use the best lubricants and the most approved means of applying them. The pressure per square inch which can safely be put on a journal must, therefore, be determined by the attending circumstances. In the case of cars, these are so complicated, that only experience can work out

the problem satisfactorily. In the consideration of this question, your Committe have not undertaken to lay down any absolute theoretical rules to be universally applied, but they wish simply to recommend a size of axle which, in their judgment, would be best suited for all the varying circumstances of railroad traffic. In deciding on such a standard, it must be remembered that we must adopt such dimensions as will give good results, under all conditions, and not only under favorable circumstances—that is when loaded with moderate loads, when provided with bearings made of good material, and lubricated with good oil, and carefully and faithfully attended to, when attention is necessary. With the present system of interchanging cars, the problem seems one of providing a standard axle which will work well under the *most unfavorable conditions.* The standard axles should be such as would be the least liable to heat or break when overloaded, when the bearings and oil are of poor material, and the attention such as the most careless, ignorant, and indolent inspector is liable to give them. Now, if these are the conditions which must be fulfilled, a large journal is certain to do it very much better than a small one. By increasing the size of the journal the pressure per square inch with any given load it also diminished, and, consequently, with any given quality of brass or oil there is more certainty of having good lubrication and less liability that the oil will be squeezed out from between the bearings.

It is of course true that by increasing the diameter of the journal the leverage of the wheel on the journal is diminished, and therefore more power is required to overcome the friction than would be needed if the journal were of small diameter. Now, undoubtedly, if it were possible to increase the surface of the journal by extending its length without enlarging the diameter, it would be better than to increase the diameter. But it is impossible to do this and retain the requisite strength and stiffness which an axle should have for safety, and to wear evenly when the axle is of iron. Probably the substitution of steel for iron may enable the smaller journal to be extended in length, and yet be of sufficient strength. It is probably true that cars provided with axles having journals smaller than these recommended for the standard will require somewhat less power to draw them with moderate loads if they are both thoroughly well lubricated. What is claimed for the large journal is that it is more

certain to remain well lubricated in ordinary practice with the excessive weights with which cars are sure to be loaded at times, and when oiled with poor oil, and with the attention they receive on the long through lines. The advantage possessed by a large journal in this respect it is believed will much more than counterbalance the disadvantage of "increased leverage."

The increased resistance from the latter cause can be shown by a simple calculation. The resistance of a car, as nearly as it is known, is about 6.1 pounds per ton of two thousand pounds at a speed of five miles per hour. Assuming that its weight is twenty such tons, the total resistance will be one hundred and twenty-two pounds. This is made up of rolling friction of the wheels on the track and of the friction of the journals. Now if we take the co-efficient of friction of the latter at 0.025, and deduct the weight of the wheels and axles, or three thousand pounds, which does not rest on the journals, from that of the car, we find that the friction of the latter will be equal to nine hundred and twenty-five pounds; which divided by the diameter of the wheels, thirty-three inches, and multiplied by that of the journal, three and one-fourth inches, will give the resistance at the tread of the wheel due to journal friction. By making the same calculation for three and three-fourth-inch journals, we find that the resistance due to the small journals is ninety-one, and for the large ones, one hundred and five pounds, or a difference of fourteen pounds, or an increase of about eleven and one-half per cent. of the total resistance. But it must be remembered that the journal friction is uniform, or very nearly so, at all speeds, whereas, the resistance to rolling of the atmosphere and the flange friction increase very rapidly with the speed. These have been calculated from a table of resistance recently published, and are given in tabular form herewith. It will be seen that at a speed of thirty miles per hour the resistance is increased six and one-fourth per cent. by the large journal, and at forty miles per hour four and one-half per cent. The same thing will be true of the resistance on grades and curves. Thus, on a grade of thirty feet per mile, and at a speed of thirty miles per hour, the resistance of the car would be increased only about three per cent. by the large journal, and at the same speed on a grade of forty feet per mile, two and one-half per cent.

Speed in miles per hour...........	Total resistance of car weighing 20 tons of 2,000 pounds.	Resistance due to journal friction with 3¼ journal.....	Resistance due to journal friction with 3¾ journal.....	Percentage of increase of resistance due to large journals...
5	122 pounds.	91 pounds.	105 pounds.	11¼
10	132 "	"	"	10½
15	146 "	"	"	9½
20	166 "	"	"	8½
25	192 "	"	"	7¼
30	224 "	"	"	6¼
35	262 "	"	"	5½
40	306 "	"	"	4½
45	356 "	"	"	4
50	412 "	"	"	3½
60	540 "	"	"	2¾

In these calculations we have assumed that the journals in each case were in a perfect condition of lubrication. If it is remembered that the friction of two surfaces which are only partly or very imperfectly lubricated is often from four to six times as great as it is when perfectly lubricated, it will be seen that a very slight difference in the conditions of the journals and their bearings may increase the resistance very much more than that due to the enlargement of the journal. In other words, enlarging the journal increases the resistance of cars at ordinary speed of say twenty to thirty miles per hour from eight and one-half to six and one-fourth per cent., whereas with imperfect lubrication the friction of the journals may be increased six hundred per cent. The importance, therefore, of securing good lubrication is obvious. That this is more certain with the use of large journals is shown by the unanimous testimony of those who replied to the circular of your Committee, and who had observed the effects of wear on the bearings of large and small journals. They are unanimous in the opinion that the bearings of the former wear better than those of smaller size.

Very great objection is, however, made to the adoption of a standard axle of the size recommended, owing to its great weight, which is about three hundred and thirty-five pounds finished. To

this objection it is thought that the greater safety to life and limb which would result from its use would alone be a sufficient answer. The attention of those who say "that we never have any broken axles" is called to the report of such breakages contained in the twenty-six replies to the Committee's circular. It should be stated that with reference to this point the recollection of some of those who replied to the Committee's inquiry seemed to be as unreliable as that of some of the witnesses in the Beecher trial. It would nevertheless be an instructive practice in single rule of three to calculate the following "sum:"

If twenty-six Master Mechanics report sixty-two broken axles, how many could the two hundred and thirty Master Mechanics in the printed list before us report?

A record of train accidents in 1874, which doubtless most of you have seen, reports twenty accidents from broken axles, and at least one member of your Committee knows how imperfect that report is. To say, then, that no accidents occur from broken axles is to ignore well-established facts.

An additional reason for selecting the standard recommended by the Master Car Builders' Association and by your Committee is the fact that it has already been adopted by a number of roads, and large numbers of those axles are now in use. The Committee are unable to give a correct list of those roads which have put it in use, but are informed that the New York Central & Hudson River, the Boston & Albany, the Boston & Providence, and the Delaware, Lackawanna & Western Railroads are using it. It will, of course, insure its general adoption very much earlier should it be recommended by your Association, whereas if the two Associations, which in this respect if in any should act harmoniously, should disagree, the time when uniformity of rolling stock can be secured will be indefinitely postponed.

On motion, the report was received.

Mr. Forney, Railroad Gazette—I wish in addition to the report to offer this resolution:

Resolved, That this Association concur with the Master Car Builders' Association in recommending the adoption of the standard for car and tender axles, which that Association has proposed, when said axles are to be made of iron.

But before that question is put I would like to report on some experiments made last week at Springfield, intended to throw some light upon this subject, but which were not very successful; however it is no more than just that a report should be made of what occurred. Messrs. Adams and Chamberlain, of the Boston & Albany Road, fitted up a number of cars with large axles and a number with small axles. The cars with the small axles were old and the wheels were old, but the axles and bearings were new. The cars with large axles were new cars throughout. They took two cars when empty, and assuming that the one with the large axle would run the furthest they put one of these cars on the incline, which is east of the Springfield depot, the grade of which is seventy feet per mile. They let it run by gravity, but put a man on who was particularly instructed not to apply the brakes unless to prevent accident. The car ran to the middle of the bridge that crosses the Connecticut River. Then they let the empty car with the small axle loose at the same point, and it would have run into the first car had they not applied the brakes. They then took a car having small journals, loaded with twenty tons, and started it from the same place; it ran down across the bridge and upon a curve on the other side, a distance of seven thousand eight hundred and ninety-seven feet. They then let the car with the large journal loose, and it ran within five hundred and forty feet of where the first car stopped, making a difference of about seven per cent. in favor of the loaded car with the small journal. The experiment was repeated with an empty car with small journals, and it ran eleven hundred and fifty-five feet, or fifteen per cent. further than the loaded one. They intended to repeat the experiments next day at Springfield, but owing to the fact that Barnum's Hippodrome was exhibiting there the depot was so crowded that they were afraid of an accident if they attempted it. The experiments were not satisfactory and will be repeated at some future time at another location. The reason the experiments were not satisfactory was this: the cars were all new and had run only the distance from Boston to Springfield. If the cars had been in service for some time the journals would have been considerably better lubricated than they were, and probably the new wheels did not run as easily as the old ones. Another reason is, that in the cars with the large journals the wheels were spread seventeen inches wider than the others, which would cause more resistance on the curve beyond the bridge. But under favorable treatment there is only a difference of seven per cent., and the difference in the distance run was less for the loaded cars than with the empty ones. We intended the next day to load a car with about fifteen tons and try the experiment again, and my impression is that had we done so it would have been about an even thing. I report these experiments simply because I think it is just that they should be known to the Association. The result, however, does not lessen my faith in large journals.

THE PRESIDENT—I think that this question should be fully discussed before we adopt the resolution recommending the standard axle.

Mr. FORNEY, Railroad Gazette—As all the members are not present I would suggest that we make the further discussion of this resolution the special order for to-day at twelve o'clock.

Carried.

THE PRESIDENT—The next business in order is the report of the Committee on Mechanical Laboratory. The Committee consists of Messrs. Robinson, Wells, Boon, Chapman, and Britton.

The report was then read by the Secretary.

Report of Committee on Mechanical Laboratory.

To the American Railway Master Mechanics' Association:

GENTLEMEN: Your Committee appointed at the last Annual Convention to continue their inquiries and deliberations on the above subject, beg to report that they issued a new circular of questions, such as was thought would best elicit the fullest opinion of the members, the following being a copy of the same:

MECHANICAL LABORATORY.

DEAR SIR: The Committee ordered to be continued at the last meeting of the American Railway Master Mechanics' Association for further inquiry into the subject of the establishment of a Mechanical Laboratory, again respectfully request such a full consideration of this subject on the part of each member of the Association, that no difficulty may be experienced in arriving at a definite and satisfactory decision during the next Convention. In order, therefore, to gather in a concise form the general or prevailing opinion of members, the Committee invite your especial attention to the chief points of the subject as contained in the following questions, to which they solicit your answers, together with any useful remarks or information you may be able to give:

1. Do you consider the establishment of a mechanical laboratory in any form whatever as a necessary adjunct to our Association?

Notwithstanding the character of your answer to the above question, your replies to the following questions will be valuable in case the establishment of such a laboratory be ultimately determined on.

2. Should such a laboratory be established as an independent institution owned and controlled entirely by this Association, or would the object in view be better served or accomplished by the laboratory forming a part of some other outside institution?

3. If a majority of the members should prefer that the laboratory be established as an independent institution, in what city do you consider its location would render the greatest benefit to members of the Association generally?

4. Do you think the railroad company in whose service you are engaged would be willing to subscribe its share (a very small sum if divided over all roads) toward the establishment and maintenance of such a laboratory, providing that its regulation and management were placed under the control of the presidents of the leading railroads as was fully explained in report of this Committee to the last Convention?

5. Do you know of any fairer or more equitable plan for providing for the first expense of establishment and maintenance of such a laboratory than the one suggested in this Committee's last report, of prorating such expenditure between all the railroads willing to subscribe in accordance with the number of locomotives each road possessed during each year?

6. Should a majority of the members intimate a preference for the laboratory to be established in connection with some other outside institution, would you be favorable to our forming a connection with the Stevens' Institute of Technology, of Hoboken, New Jersey, taking advantage of the arrangements suggested by Professor Thurston, or do you know of any other institute offering facilities which you think preferable to those of the Stevens' Institute?

7. In the event of the majority deciding to take advantage of the privileges offered by the Stevens' Institute, and it being understood that the Association in such case would have no special control over any contributions it may make to the laboratory of that institute beyond facilities under certain regulations to conduct experiments, would you vote for appropriating at next Convention any portion of the balance of the funds of the Association as a special contribution

to the laboratory of the Stevens' Institute of Technology? If so, what amount would you suggest?

Yours faithfully,

W. A. ROBINSON, *G. W. R. R., of Canada,*
R. WELLS, *Jeffersonville, Madison & Indianapolis,*
J. M. BOON, *Pittsburgh, Fort Wayne & Chicago,*
N. E. CHAPMAN, *Cleveland & Pittsburgh,*
H. M. BRITTON, *Whitewater Valley.*
} *Committee.*

Please address replies not later than March 1st to

W. A. ROBINSON, *Mechanical Superintendent G. W. R. R.,*
Hamilton, Ontario, Canada.

In view of the very interesting discussion that took place upon the report presented last year in Chicago, it was fully expected that a large majority of the members would have favored us with replies, but we regret that such hopes were not realized, so that in truth so far as help from the members generally is concerned, the Committee have been very little advanced from the position occupied last year. So far as received, replies indicate very unmistakably that the subject is one for which the Association is not sufficiently matured at the present time to receive; for, while six-eighths of the answers are in favor of the establishment of a mechanical laboratory and five-eighths recommend it to be in connection with the Stevens' Institute, yet six-eighths are not favorable to voting any of the funds of the Association toward such object, which thus practically means taking no action at all.

In accordance with the minutes of the proceedings of last Convention (see page 161 of last Annual Report) your Committee have communicated with the American Society of Civil Engineers, and from replies received, it would appear that no definite action has yet been taken by that Society in regard to the suggestion of the Stevens' Institute.

After a careful reconsideration, your Committee deem it the wisest course at the present time to recommend that this subject be postponed, either indefinitely, or until surer prospects exist of its being successfully carried out.

W. A. ROBINSON,
R. WELLS,
J. M. BOON,
N. E. CHAPMAN,
H. M. BRITTON.
} *Committee.*

On motion, the report was accepted.

Mr. LAUDER, Northern New Hampshire Railroad—Mr. President, on inquiry of the Assessment Committee I find that they have not made much progress in the matter of collecting the assessments due from the members, and inasmuch as that Committee was appointed in the early part of the session when there were comparatively but few members present, and a large number of members have since come into the hall, it is probably not known by all that we have such a Committee to whom their assessments can be paid. I am afraid that if we delay this matter it will place more business in our hands at the closing hours of the session than we will want. I therefore move a recess of five minutes to enable the members who have not paid their dues to do so now. The Assessment Committee will be found at the left of the hall.

THE PRESIDENT—I wish to state to those present who are entitled by our Constitution to membership in this Association, that they can become members by applying to the Secretary at this time.

The motion was then carried and a recess taken.

On re-assembling, on motion of Mr. Brooks, ex-Governor Bigler, who was present in the hall, was invited to address the Convention.

THE PRESIDENT—Gentlemen, I have the pleasure of introducing to you ex-Governor Bigler, of Pennsylvania.

Ex-Governor BIGLER—Mr. President and gentlemen, it might reasonably be considered presumption in me to appear before you, because I am not a mechanic in the usual sense of the term. I belong, however, to that fraternity which has usually been in the habit of saying about what they please in reference to mechanics and other people. I am a printer, a type-sticker. I have felt, however, a great interest in every organization of this kind during my whole life, and I regret that I have not had an opportunity to look into your mode of proceeding so as to be able to talk to you about what most nearly interests you. I know, however, that your organization is intended to gather up the results of experience throughout the entire country of the the different railroads, in order to compare those results and accept the lessons which experience teaches. I do not know any thing more commendable or profitable in which you could be engaged, and I have very little doubt that you see the practical results attending the efforts of your organization, which are of benefit, not only to yourselves, but to all the great industries with which you are allied. I am not sufficiently familiar with your department of industry to talk about it, but I do know that a plan so perfect in theory as yours seems to be, and relating to branches so vital and important, can not fail to produce results of the greatest value. Gentlemen, it is my fortune, or perhaps it is my misfortune at this time of my life, to be engaged in a most laborious semi-official duty. I am one of those who have accepted the trust granted by the Congress of the United States with refer-

ence to the celebration of the Centennial Anniversary of the Declaration of Independence, and I am going about over the country with reference to this work. I look upon this organization as a type, and as a very fitting type of the means to that celebration, because that means is an exhibition of arts and manufactures, an international exhibition, an exhibition that brings all the world together to compare results. In this regard we look to you as a special power. You feel the utmost interest in all that affects the mechanics of the country. I therefore confess to a little weakness in my desire to elicit your interest and aid in the matter in which I am engaged. Railroads, and the perfection of railroad communication in every department, is an achievement which we are about to commemorate and celebrate. Railroads, with their great locomotives and appendages, were not common in the last century. Our fathers did not travel in that way before the adoption of the Declaration of Independence. The achievements of the railroad and of the telegraph are among the most remarkable incidents of the century. I have promised to occupy only a very few minutes and I must therefore come to the practical working of this Centennial Exposition. We are before the country under the laws of Congress, and I take the liberty of saying that those intrusted with this celebration and with this international exhibition are proceeding according to law. I am here under the duty imposed upon me by the laws, and those laws make my duty co-extensive with the entire country. The preparations for the celebration commenced long since. The buildings are in process of erection, and there is nothing needed to make the preparations equal to any thing the world has yet seen except that we need more money. Congress seemed to be impressed with the idea, and it is a very beautiful idea, but it does not seem to work so well in practice, that it would be fitting for the people of the United States by their own volition to furnish eight or ten millions of dollars to commemorate the founding of this Government. It is a beautiful idea and I hope it will be successful, but to make it successful requires this kind of labor and presumption that I am practicing this morning. We have to go before every body in the country, and, expressing our needs, implore help. I know that you, gentlemen, are a power in the land. As for railroads, they should be very helpful because they will be great beneficiaries of this celebration, for they will have during that year an immense special business which would not come to it but for these Centennial ceremonies. I know that you can create the impression because they are to be thus benefited they ought to be quite generous in helping us. The mode of raising capital prescribed by Congress was the creation of a corporation with the right to sell capital stock to the extent of ten millions of dollars, and that is what we are endeavoring to do. We want to sell a million and a half or two millions more. The amount of capital already raised is about five millions. Three millions of that sum is a contribution not represented by stock at all. The city of Philadelphia and the State of Pennsylvania contributed directly two and a half millions towards

the erection of the buildings, receiving no stock in return and expecting to get nothing back. This leaves the chance better for those who hold the stock. There is in the object itself enough to inspire the American heart. If we had only time to talk about the incidents preceding the War of Independence, the struggles, hardships, and privations of that war, we could bring ourselves up to an appreciation of what our fathers did for us, which would induce us to help make this a very complete success without stopping to inquire whether we are going to get any of the money back again. A more dignified and fitting mode could not be devised for honoring the memory of the men who had the courage to declare for and the endurance to establish our independence on the basis of self-government. It is an event that ought to be commemorated. In fact, no event of modern times is more worthy of notice. Not only for these reasons, but because of the lessons which it will teach us, we ought to give our efforts and money to make this exhibition a success. Such an enterprise will not only be harmonizing to our countrymen, but it will have an educating influence, because of the exchange of what is accomplished in one country with what is accomplished in another. The state of the arts, sciences, and manufactures throughout the entire world is to be made apparent in the midst of this young republic, and we are to look upon the exhibition and receive the lessons which it may teach us. You, gentlemen, are the best type of an international exhibition that I can discover in the affairs of the country just now, therefore resembling somewhat this international exhibition in its teachings and purposes. I trust that from a feeling of identity you will be led to get as close to it as you can, and to extend to it your strong arms of help. I will remark in conclusion that three or four months ago it was deemed expedient to divide the labors of the Centennial Board, and to place one branch of it in New York. I am at the head of the New York Branch, and am at the Centennial Headquarters at the St. Nicholas Hotel, where you can get, if you choose, certificates of stock. The certificates are emblematic and significant of the progress of the country, showing the amazing change that has been accomplished. We have these certificates in single shares, not so much for the purpose of profit as of a memorial. We have also some lithographs of the buildings which are being erected, and pamphlets relating to the exhibition which I shall be happy to furnish to every member of this Association. With these remarks I will take leave of you, thanking you first for your courtesy and feeling that I am indeed honored by the opportunity. Mr. President and gentlemen, I thank you for your kind attention.

THE PRESIDENT—The Committee on Subjects for the Next Year is ready to report. The Secretary will read the report.

Report of Committee on Subjects.

To the American Railway Master Mechanics' Association:

GENTLEMEN: Your Committee appointed to select subjects for investigation during the coming year, beg leave to present the following subjects as being, in their opinion, worthy of careful and thorough investigation:

1. Locomotive Tests.
2. Best Material, Form and Proportion of Locomotive Boilers and Fire Boxes.
3. Locomotive Construction.
4. Locomotive Tire, Truck and Tender Wheels.
5. Best and Most Economical Metal for Locomotive and Tender Journal Bearings.
6. Is it Economical to Use Injectors on Locomotives, and to what extent?
7. Boiler Explosions.

Respectfully,

R. WELLS,
JAMES BOON,
JOHN FLYNN, } *Committee.*

On motion, the report was received and adopted.

Mr. BROOKS, Brooks Locomotive Works—Mr. President, I wish to offer the following resolution:

Resolved, That the Boston Fund, amounting now, with accrued interest, to $3,620, be invested in Government securities, to be selected by the duly appointed trustees, and not to be disturbed for the purpose of expenditure unless authorized by the majority of the members present in open Convention, and then only after due notice of a motion to expend the same has been given at the session immediately preceding. The interest, however, derived from such securities may be expended by the trustees when necessary to meet any current expenses of the Association, provided a full account of the same be duly reported along with other financial statements.

THE PRESIDENT—You have heard the resolution. I will state, for the information of members who may know nothing about it, that in 1872 a fund of $3,000 was presented by the citizens of Boston. The fund has been kept on interest until the present time, and it now amounts to $3,620. It was thought by many of the members that the fund should not be disturbed. Consequently Mr. Brooks has offered the resolution, which you have heard, that it shall not be disturbed unless a majority of the members of the Convention vote to use it. Are you ready for the question?

Mr. FORNEY, Railroad Gazette—I would like to amend the resolution by inserting the words, "After twenty-four hours notice;" otherwise I think there is hardly sufficient security for the fund. A few members might get together and move to make use of that fund, and do so without the other members knowing any thing about it. But by requiring twenty-four hours' notice of a motion to use it, all members would have an opportunity to become acquainted with the proposed action.

Mr. BROOKS, Brooks Locomotive Works—I will accept the amendment—"and not until after the subject has been brought up at a previous meeting." That will cover the ground.

Mr. FLYNN, Western & Atlantic Railroad—I am a strong advocate of that resolution, but I would like to amend it. The amendment that I would offer is this: "That the yearly interest be invested every year as a sinking fund, the same as the principal." I have the honor to belong to an Association that commenced with a sinking fund of $500. I have now been a member for about ten years, and that sum has been augmented until it now amounts to nearly $4,000. I think there is sufficient devotion to the interests of our Association to prompt each and every member to pay all the assessments that may be made to defray our expenses, even if the assessments should go over $10 per year. I think that no member will object to paying his share of all necessary expenses. The fund which we now have, if left to accumulate, will become, in future years, a fund from which great good can be gained. Instead of being $2,000 or $3,000, it will become $20,000 or $30,000. This Association, though comparatively small in numbers at present, may then be much larger. We all know that where an Association has financial ability it adds to its influence and to its force. Men have a stronger desire to become acquainted with it, and to become members of it. I have found it so in my own experience in life, and I doubt not that it is the experience of every other member. I can see no necessity for expending any of the income derived from this fund. I think it should be left to accumulate for the benefit of the society in future years. I would, therefore, suggest that the resolution be amended by providing that the yearly income shall be invested with the principal, so as to make both principal and interest a sinking fund. I therefore offer as an amendment to that resolution, "That the interest accumulating shall every year be invested in the same manner as the principal."

Mr. BROOKS, Brooks Locomotive Works—The amendment of Mr. Flynn perfectly coincides with my own views in regard to this matter, but at the same time there are several members in the Convention, I do not know how many in number, who have thought hitherto that the money should be expended for our necessary expenses, and this resolution is a sort of harmonizer of the two elements. If the resolution can be passed with the amendment suggested by Mr. Flynn I should be much better pleased.

Mr. FLYNN, Western & Atlantic Railroad—I am glad that Mr. Brooks

coincides with my sentiment. I think it should be favored by each and every member of the Association who knows the power that accumulated wealth gives to an association of this character. I think those who appreciate this fact can not have an objection to investing the interest with the principal from year to year. If any of you have been connected with an association of the character that I have indicated, commencing with a small fund and running along for years, you have had a chance to know the value and influence that such a fund gives. We all know that money multiplies, and the advantage of having an accumulated fund is one that we should be anxious to avail ourselves of. I, for one, am desirous of this, and sincerely hope that each and every member of the society will take the same view of the matter that I do. If we increase the fund in this way many of us will live to see the day when it will give power and influence to the Association.

THE PRESIDENT—Gentlemen, the question is on the amendment.

Mr. ROBINSON, Great Western of Canada—I know the present trustees of this fund, but of course I do not know who will be the trustees for the ensuing year. I know that the present trustees have invested the interest with the principal. If they are continued in office it is their intention to continue to invest the interest as well as the principal. The resolution was simply intended to make a provision in case of necessity. There is no intention whatever of making any use of the interest, except to reinvest it with the general principal. If Mr. Flynn's amendment is carried, of course it entirely precludes any such use of the interest as that named, although at the same time there is no present intention of using it. I do not think that the members of the Association would be willing to see the fund used for our current expenses, as has been suggested.

Mr. FLYNN, Western & Atlantic Railroad—My idea is to make it obligatory upon the trustees to invest the principal. We do it in the association to which I referred. The time may come when our financial condition might need an expenditure of that interest, but in the mean time it is better that each individual member should bear his proportionate share of the expenses, whether they be more or less. I do not propose, in my amendment to the resolution, to give the trustees any authority to use the money, but my object is to take the power to use it out of the hands of the trustees.

The amendment suggested by Mr. Flynn was agreed to, and the resolution, as amended, adopted.

The Chairman of the Committee on the next place of meeting made the following report:

Report on Next Place of Meeting.

To the American Railway Master Mechanics' Association:

GENTLEMEN: The Committee appointed to report places of meeting, respectfully beg leave to name:

St. Louis, Philadelphia, Augusta, Providence, and Cincinnati.

B. W. HEALY,
J. U. EASTMAN,
R. W. BUSHNELL, } *Committee.*

Report received.

THE PRESIDENT—You have heard the report. How will you select the place?

Mr. BROOKS, Brooks Locomotive Works—I would suggest that Cincinnati or St. Louis be chosen as the place of meeting two years from now instead of next year, as that arrangement would enable members to attend the Musical Festival which is to be held in Cincinnati at that time as well as the Convention. That festival is held only once in two years, and will be again held in 1877. I am in favor of an Eastern locality for next year.

Mr. SELLERS, of Philadelphia—It seems to me that it would be better for the members to meet in Philadelphia or some where near there on account of the Centennial. There will be so much to be seen there at that time that the members will be anxious to visit Philadelphia; and the people of Philadelphia are very anxious to have the Convention there if the proper accommodation can be found. If the Convention does not select Philadelphia as the next place of meeting it would be better to select some place of easy access to it. I do not see why the Philadelphians, with their hospitality, should not be able to accommodate members at their houses if they were unable to find accommodation at the hotels.

Mr. BROOKS, Brooks Locomotive Works—The only objection to Philadelphia would be the probable want of accommodation there. The city at that time will be so fearfully crowded that we may not be able to find room.

Mr. FORNEY, Railroad Gazette—Vienna was not crowded at the last Exposition.

Mr. SETCHEL, Little Miami Railroad—I move that Providence be selected by acclamation.

Mr. FRY, Philadelphia & Erie Railroad—I beg leave to move as an amendment that Philadelphia be selected by acclamation. We shall all have to go to Philadelphia next year, and we may be able to find a place for our meeting just as well then as at any time.

Mr. FLYNN, Western & Atlantic Railroad—I hope that Mr. Fry's amendment will not be adopted, for Philadelphia will be so crowded that it will be difficult for us to be comfortable there, but I think it will be possible for us to meet at Atlantic City, Pittsburgh, or Reading, and still accomplish the

object which Mr. Fry has in view. I have never been at Atlantic City myself, but I think that being on the sea-shore, it would be quite desirable as a place of meeting.

Mr. SPRAGUE, of Pittsburgh—I think that in justice to the Western members we should hold our next Convention in the West. We have not a very large delegation of Western members here, and if we stay East too long we may alienate some of them from us. I think in justice to them we ought to meet some where in the West.

Mr. FLYNN, Western & Atlantic Railroad—It would be my desire that the Association meet South the coming year, but as strong as that desire is, I have a feeling of patriotism which draws me to the city of Philadelphia on the Centennial Anniversary. I think it would be impolitic for us to meet in Philadelphia on account of the crowded condition of the city at that time, but we might seek a place convenient to Philadelphia. My desire to have the Association meet in the South flows from this cause. I have a wish that the men representing the mechanical operation of the railroads from that section should attend in larger numbers than they have at our previous Conventions. I trust that some member who is more competent to judge what would be the best location will suggest it. The consideration determining the selection should be its easy access to Philadelphia during the Centennial celebration.

Mr. SPRAGUE, of Pittsburgh—If the Convention is to be held as early as we are holding it this year, I think that there will be plenty of room in Philadelphia. It will be crowded in July and August, but I think there will be plenty of room in May for the members of this Association. There will probably be accommodation for a great many more people than are likely to be there in the month of May, and therefore I think there will be no difficulty in meeting in Philadelphia in that month.

The motion designating Philadelphia as the next place of meeting was then agreed to.

Mr. BROOKS, Brooks Locomotive Works—I am informed that the time of the opening of the Centennial has been postponed from the 19th of April to the 10th of May, and it is possible that another postponement may be made which would make the Centennial celebration a few weeks after we would hold our Convention. That would make us all feel very cheap; I would, therefore, move that there be no further postponement of the Centennial. (Laughter.)

Mr. SELLERS, of Philadelphia—Might it not be well in view of a possible postponement to have the officers of the Association notify the members in that case that the meeting of our Association will also be delayed. For my part I think there is no possibility of any further postponement of the Centennial. The buildings are progressing rapidly as compared with those in Vienna, and there seems to be no question of doubt that the build-

ings will be ready for occupancy at the time set. I would offer a resolution that it be in the power of the Committee to change the time of meeting if such a thing be in accordance with the by-laws.

THE PRESIDENT—The Constitution provides that the regular meetings of the Association shall be held annually on the second Tuesdays in May.

Mr. SELLERS, of Philadelphia—I think that the Convention in Boston was not held on the second Tuesday, but that it was postponed on account of the Musical Festival, and the same thing can be done now.

Mr. SETCHEL, Little Miami Railroad—That meeting was changed by vote of the Association. The question was laid before each member of the Association and a vote taken on it, and when the vote came in a decision was made in accordance therewith.

Mr. SELLERS, of Philadelphia—Then that can be done in the present case. It seems to me that it would be a very unwise thing to have the members meet in Philadelphia at a time when they could not see the Centennial Exhibition.

THE PRESIDENT—There would be no harm in changing the time of meeting to the second Tuesday in June. The Constitution may be amended at any regular meeting by two-thirds of the members present.

Mr. SELLERS, of Philadelphia—I would not advise it to be held in June without any possibility of changing it. If the Centennial is open in May it would be pleasanter to meet in May than in June.

THE PRESIDENT—As all the members will want to attend the Centennial it would be well to offer a resolution that in case of the postponement of the Centennial celebration, the officers be instructed to notify each member of the postponement of the time of meeting not exceeding one month.

Mr. SELLERS, of Philadelphia—Then I would offer that as a resolution as the Chair has stated it.

THE PRESIDENT—Mr. Sellers offers the resolution, that, in case the Centennial celebration is postponed, the officers of this Association shall notify each member thereof of a postponement of the time of meeting of the Convention not exceeding one month from the second Tuesday in May.

The resolution was adopted.

THE PRESIDENT—The next business before the Association will be the report of the Committee which was appointed yesterday on Axle Tests. That Committee consisted of ten members. Is the Committee ready to report?

Mr. HAYES, Illinois Central Railroad—The Committee appointed yesterday to witness the tests of axles are ready to report, and the report is in the hands of Mr. Sellers.

THE PRESIDENT—Mr. Sellers will please read the report.

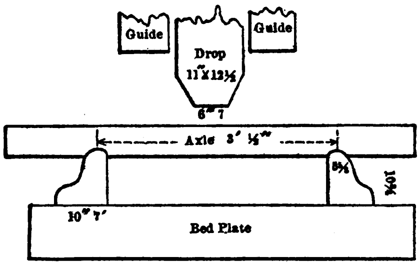
Mr. SELLERS, of Philadelphia—That is a very judicious request inasmuch as I acted as secretary, and I do not think that any body else can read it.

Mr. Sellers then read the following report:

Report of Committee on Axle Tests.

To the American Railway Master Mechanics' Association:

GENTLEMEN: Your Committee, to whom was referred the Tests of Steel and Iron Axles, beg leave to report that they visited the shipyards of Mr. John Roach, on the afternoon of Wednesday, May 12th, and found that preparations had been made to test the axles by a drop, which may be described as consisting of a heavy cast-iron bed plate, upon which was erected two cast-iron standards, thus:



The weight of the drop hammer was given at seventeen hundred pounds, and it was arranged to slide freely in wooden ways, so arranged as to permit of about thirty-four feet elevation of the lower face of the drop above the axle to be tested. The ways were laid out in feet to facilitate the adjusting of the height of fall. The drop was raised by a portable steam engine placed near by and provided with a let-go lock after the manner of iron breaking drops. The axles submitted for test were as follows:

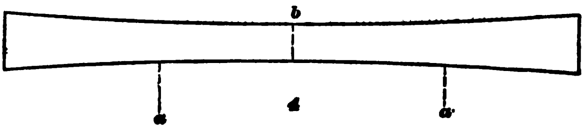
IRON AXLES.

Two members of the Association desiring to test the relative merits of iron and steel, selected iron axles from two different makers, both said to be of good quality, and which are designated by your Committee as Nos. 1 and 2 respectively. We mention this to show that the Midvale Steel Works did not place iron axles in competition with their own.

STEEL AXLES,

From the Midvale Steel Works at Philadelphia. The first test was

of a bar of round steel four and one-sixteenth inches diameter over its whole length, and five feet three inches long. This and all the axles tested were marked with chalk in center, and at points two feet on each side of the center mark, thus:



a a four feet apart: *b*, mark in the axle.

The marks *a* were to indicate the line from which the deflection should be measured. Thus, in all cases, giving the deflection in a bar four feet long.

The result of the test of this bar was as follows:

First blow, 25 feet drop, $6\frac{3}{4}$ inches deflection.

Reversing the bend for the succeeding blow:

Second blow, 25 feet drop, straightened the bend from first blow, and bent it within $\frac{3}{16}$ of an inch straight; a curvature of $\frac{5}{8}$ of an inch laterally.

Third blow, 25 feet drop, deflected the bar $5\frac{3}{8}$ inches.
Fourth " 25 " " " " $1\frac{5}{8}$ "
Fifth " 25 " " " " $4\frac{15}{16}$ "
Sixth " 34 " " " " $3\frac{3}{8}$ "
Seventh " 34 " " " " $4\frac{3}{4}$ "

The bar at the end of this experiment showed no sign of breaking, and was laid aside.

The second test was of a round bar of iron of Brand No. 1, measuring four and three-sixteenth inches diameter throughout its length:

First blow, 25 feet, bent it 7 inches.
Second " 25 " " $\frac{1}{2}$ inch, i. e. within half an inch of being straight.
Third blow, 25 feet, bent it 7 inches.
Fourth " 25 " " $\frac{5}{8}$ of an inch, with a crack showing on under side of bar.
Fifth blow, 25 feet, fractured the bar.

The iron seemed to be of a very good quality.

The third test was with an iron axle, Brand No. 2, said to have been of good quality, and but one axle of the same make had broken

in fifteen years' experience. The axle measured three and thirteen-sixteenth inches in middle and at ends four and five-eight inches :

First drop of 25 feet bent it 9½ inches, and cracked it.
Second " 25 " separated the parts.

The iron seemed sound and of good quality.

The fourth test was of an axle by same makers, which had been in use, bearing date of manufacture, September, 1873. This was four inches in center and four and five-eight inches at ends:

First blow, 25 feet drop, bent 8¾ inches, cracking it so badly as to render a second fall useless.

The fifth test was applied to a steel axle made by the Midvale Steel Works, four inches in middle and four and fifteen-sixteenth inches at ends:

First drop, 25 feet, bent it 6⅞ inches.
Second " 25 " straightened it.
Third " 25 " bent it 6½ inches.

At this point of the proceeding your Committee consented to the length of fall being increased to facilitate the fracture, so that all succeeding blows were given at a fall of thirty-four feet:

Fourth blow,	34 feet drop,	deflected it	2⅞	inches.
Fifth "	34 "	"	6¼	"
Sixth "	34 "	"	3⅝	"
Seventh "	without reversing,	"	9⅞	"
Eighth "	reversed,	"	1⅞	"
Ninth "	not reversed,	"	5⅜	"
Tenth "	"	"	12⅛	"
Eleventh "	reversed, fractured the axle.			

The section at fracture measuring across the face three and eleven-sixteenths by three and fifteen-sixteenth inches.

The sixth test was with a new iron axle of brand No. 1, measuring four and one-sixteenth inches in center and five inches at ends. This was tried with a fall of thirty-four feet:

First blow, 34 feet drop, bent it 10⅛ inches.
Second " 34 " broke the axle.

Iron seemed very good.

Your Committee were shown specimens of steel, said to be the

same as is used in the axles tested. These specimens were in the hands of Professor R. H. Thurston, of the Stevens' Institute of Technology, and had been tested by him with the following results :

Laboratory number..	Proprietor's mark	Limit of elasticity..	Ultimate strength.....	Elongation maximum	Equivalent reduced section................	Molecules of resilience
391	747	40,100	69,500	0.4401	0.694	19,705
392	750	33,000	68,000	0.8254	0.548	36,317
393	743	48,400	65,500	0.3657	0.734	15,518
394	750	50,800	70,292			21,647
			102,775	0.4615	from 44,173 to 30,202	
395	747	38,575	65,968			51,147
			142,643	1.163	44,173 to 20,428	
396	743	40,647	65,393			50,706
			171,309	1.163	44,173 to 20,428	

Nos. 391, 392, 393 were tested in the autographic testing machine, and 394, 395, 396 by tension.

These specimens of axle steel, forwarded to the Mechanical Laboratory by the Superintendent of Midvale Steel Works, are remarkable for their homogeneousness and their extraordinary ductility. Their strain diagrams exhibit a regularity that is very unusual, and a ductility which I have never seen equaled in any thing except the softest and most ductile of wrought iron.

[Signed.] R. H. THURSTON.

Your Committee beg leave to call attention to the fact that a twenty-five feet fall on the steel which had four and one-sixteenth inches diameter bent it six and three-fourths inches, while subsequent blows bent it less, while with the iron bar which stood the test, and which measured one-eighth inch more in diameter, the first blow of twenty-five feet bent it seven inches, showing the steel axle

to be somewhat stiffer than the best iron axle tested, and yet preserving very much greater power of endurance.

Respectfully,

S. J. HAYES,	GEO. RICHARDS,
M. N. FORNEY,	ROBT. WALLACE,
COLEMAN SELLERS,	J. W. PHILBRICK,
GORDON H. NOTT,	DAVID CLARK,
HOWARD FRY,	H. GARFIELD.

The report was accepted.

THE PRESIDENT—The time for discussing the resolution offered by Mr. Forney was fixed at 12 o'clock to-day, and is now in order.

The resolution is:

Resolved, That this Association concur with the Master Car Builders' Association recommending the adpotion of the standard for car and tender axles which that Association has proposed, when said axles are to be made of iron.

I will state to those members who were not present this morning that the discussion of this resolution was deferred until later in the day, so that all might have an opportunity of voting upon it. The object is to ascertain whether this Association will adopt the standard axle proposed by the Master Car Builders' Association. Are you ready for the question?

Mr. CASSCADDIN, Chicago, Rock Island, & Pacific Railroad—I do not remember what the standard was.

Mr. FORNEY, Railroad Gazette—The journal is three and three-fourth inches by seven.

THE PRESIDENT—What is the length over all?

Mr. FORNEY, Railroad Gazette—I have not a memorandum with me which enables me to give the length, but the journal is three and three-fourth inches by seven. The dimensions are given in last year's report: Total length over all, six feet eleven and one-fourth inches; journal, three and three-fourths inches in diameter by seven inches long; wheel-seat, four and seven-eight inches in diameter by eight inches long; diameter in center, four inches; collar, four and three-fourth inches in diameter by five-eighths of an inch thick.

Mr. SELLERS, of Philadelphia—As a member of that Committee I would like to say a few words about the advisability of adopting this resolution. I perfectly agreed with the proposition to submit such a resolution in order that it might be voted upon, but at the same time I think that if the gentlemen voted it down it would not entirely end the matter. There are a great many things to be considered in determining what shall be the standard axle. For my own part I think that the size of the journal as recommended should

be adopted, but yet I am very unwilling to say that I would recommend the axle in all respects as designated. It is well to proceed slowly in making such radical changes. There may be further light thrown upon what is the proper form of axle, and also as to the distance that the journals should be from the wheels; and I very much prefer, if we adopt a resolution expressing our view, that it should be in regard to the extent of the journal rather than the whole axle. There is now a fair chance of steel being produced in the market cheaper than heretofore, and if steel axles come into use it is possible that the original size of the journal, when iron was used, might be maintained, and an increased strength be the result in consequence of using a stronger metal. I do not say that that is so, but it seems that it would be wise to have the question kept open a little longer, and I should be rather loath to have the Association adopt any thing that we are not sure can be carried out.

Mr. Forney drew upon the board a sketch of the proposed standard axle.

Mr. PEDDLE, Terre Haute & Indianapolis Railroad—Is there not a mistake made in regard to the weight of that axle, as stated in the report? The Committee stated it to be three hundred and thirty-five pounds, but I think that can not be correct.

Mr. FORNEY, Railroad Gazette—That weight was given to me by Mr. Hoit, of the Illinois Central Road. They have modified the form of the axle between the wheels very much by bringing it down a little smaller. They have reduced the weight slightly from the figures by the Car Builders' Association.

Mr. HAYES, Illinois Central Railroad—I am pretty well satisfied that Mr. Forney is mistaken with regard to the weight of the axle. The axle used by the Illinois Central Road is three and three-fourth inches in diameter by six inches long, and wheel-seat four and one-half inches in diameter, and diameter in center four inches. That axle averages three hundred and forty-three pounds in the rough. A vote in favor of adopting this axle would seem to make it almost obligatory upon the roads which we represent to adopt the size of axle that we might agree upon, and I should not be willing, upon my own account, to vote for such adoption, because we now have axles that we know are safe and good. We have some five thousand cars, all of which, together with our tenders, use the axle I have described. While I might agree with the Committee upon a standard axle, I can not understandingly vote that our road should go to work and throw away all the axles now in use and adopt the standard. We all know that the adoption of a different standard would be very expensive to a road, and that companies would not be willing to incur an expense of that kind. I know that our company would not be willing to make the change, because we now have an axle that very seldom, if ever, breaks. To my recollection we have broken only two or three in eighteen or nineteen years under passenger cars. We have

broken but very few under freight cars. Our usual time of service is two and a half years under passenger cars, and then they are turned over to the freight cars. The term of service under tenders is the same. I would like to understand that if we vote for the standard axle recommended by this Committee, such vote does not bind us to adopt that axle.

Mr. SEDGLEY, Lake Shore & Michigan Southern Railroad—I am very glad to hear the remarks of the gentleman from the Illinois Central Road, and I for another can not see my way clear to vote for the adoption of the standard axle. Where the axle has been put in use on our road, under heavy cars, it has not given as good satisfaction as a small journal. There are many reasons why I could not vote for the axle proposed; it increases the heft. We must change our pattern for wheels, or must put more iron around the hub if we adopt this axle. I do not think that the axle is as good as our present style—I think the one we are now using is the best that can be adopted. If my memory serves me right, out of an equipment of ten thousand cars, many of which have been in use for a long while, our depreciation of axles does not exceed three per cent. under a heavy service. If that is the case I see no good reason why we should increase the size of our axle twenty-five per cent., and increase the wheel perhaps in a like proportion. I would like to hear from some member of the Association who has had experience with that axle—I would like to have him give some reason if he can for our adopting it. Because the Car Masters have made a mistake in proposing that axle I see no reason why we should adopt it.

Mr. FLYNN, Western & Atlantic Railroad—It strikes me very forcibly that there should be two sizes of axles recommended by the Committee. It is a well known fact that with few exceptions the standard gauge in the South is five feet—it is true we could increase the length of the axle in proportion to suit that. I can not say, with all due respect to the Committee hat I look upon the adoption of the proposed axle with favor. Practice has taught me that an axle of a little different dimensions suits very well. The standard axle on our road, as far as the journals and dimensions go, is a journal six inches long, three and one-half inches in diameter, wheel-seat four and three-eight inches, and we use a four and one-half inch axle. That axle has answered every purpose remarkably well. Shortly after the war I dictated a length suitable for the road. Previous to that time the diameter of the journal was the same as the diameter of the present axle. I find that the axle and journal now used works remarkably well. The journal is three and one-half inches in diameter by six inches long. Mr. Hayes remarks that two and one-half inches was the diameter of the axle used under the tenders on his road. Our road, as is known to many of the members, is a succession of curves from one end to the other. There is very little straight line upon it—we all know that such short and frequent curves are a severe test to an axle. Perhaps it would be as well as adopting the report of this Committee simply to recommend that the Master Mechanics use, where they

can, the shape of axle given. In our tenders we have adopted a uniform length of axle, and I feel very little disposition to change. In fact I do not know that I would change, even if the Association passed a resolution making it obligatory upon the members to adopt that size of axle. I can not see the advantage of a seven inch bearing over a six inch, although it is true that where we distribute the friction over a greater surface the wear is not so great. I think that we might receive the report of the Committee, and recommend it to such members as have an opportunity to adopt that length of axle.

THE PRESIDENT—I would state that the Committee's report has been received, and the Committee recommended the adoption of the resolution which has been read. It is a recommendation only.

Mr. WILDER, Erie Railroad—I would like to know why that particular size of wheel-seat was adopted. Was it because of the increased size of the journal, and with a view to keep the proportion the same as in the old journal, or was it to get a stronger axle? If the object to be obtained by this new axle is simply to increase the size of the journal in favor of lubrication, why can it not be done with the old size? This new wheel-seat is four and seven-eight inches; the old size is four and three-eight inches. Thus there is a recommendation of a wheel-seat half an inch larger. The axle could be brought up to the size now recommended, but I do not see the necessity for increasing the size of the wheel-seat.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—I think if we are not satisfied with the axle that has been adopted by the Master Car Builders' Association, and are not satisfied that it is the best size that can be adopted, we ought not recommend it, for we ought not as an Association give it as our opinion that that is the size that should be used, unless we believe it is under all circumstances the *best* size. It seem to me if we can carry loads safely upon axles that are four and three-eight inches diameter at the wheel-seat, that there is no necessity for increasing the axle and incurring the expense of carrying the additional dead weight that there is in an axle of the size recommended by the Committee. They have presented no evidence conclusive to my mind that the size which they have adopted is any better than other sizes adopted by the various roads running in the country. This matter of changing the size of axles is a matter which is not in the power of the Master Mechanics to accomplish. Our company owns a large number of cars; they have adopted a standard size, and the roads with which they are connected use the same size, and it would be almost out of the question for them to adopt a different standard. As to committing the members of the Association to the adoption of that size, I am opposed, under existing circumstances, to doing.

Mr. ROBINSON, Great Western of Canada—I would like to ask Mr. Forney whether the size or dimensions of this axle was the result of any tests, or whether it happened to be the size of some axle in use upon some road. Is

the size of the standard axle based upon any theory? I ask this because I notice that there are odd quarter inches in it—six feet eleven and one-fourth inches. That is not a Master Mechanic's ideal of dimensions.

Mr. FORNEY, Railroad Gazette—As far as I know there were no theoretical considerations that brought about the adoption of that size. It was more of a compromise between conflicting ideas. At the time it was adopted there were a certain number of people who were in favor of a four by seven-inch journal. Others preferred three and one-half by seven inches, and they finally agreed on three and three-fourths by seven. I think the total length of the axle is due to the distance between the collars, making the length between the collars over the journals six feet ten inches.

Mr. WOOD, of New York City—I was present at the Master Car Builders' meeting in which this length of an axle was adopted. For the benefit of the Convention I will state that there were some fifty different lengths of axles and sizes of journals given in their lists at the time they made their selection. The great difficulty was to get a uniform length of axle; the fifty odd samples given varying as much as five inches. After having fixed the length of the journal or rather the length of the axle between the outside collars at six feet ten inches, the size of the journal was then adopted. Quite a number of Master Car Builders were in favor of a four by eight-inch journal, and they varied from that size to three and one-fourth by seven inches. A compromise was finally fixed upon of three and three-fourths by seven-inch journal. Next in order came the size of the wheel-seat. That was increased from four and three-eight inches up to as high as five inches, the latter size being recommended by a few. It was entirely owing to the percentage of failures, of axles breaking out inside of the collar in almost every case reported, so that the size of the wheel-seat for that reason was increased. The weight of the finished axle adopted by the Car Builders' Association was three hundred and forty-five pounds on the average. There were some modifications on the Harlem road and on the New York Central road, reducing the weight a few pounds; but about three hundred and forty-five pounds may be considered as light as an axle of that kind may be finished.

Mr. CASSCADDIN, Chicago, Rock Island & Pacific Railroad—In my repairs or in building and putting in axles, the first idea is to consider how I can make an axle that will do the work with less liability to break. Like Mr. Sedgely and others I am opposed to that kind of a car axle, and I think we ought not to adopt it. I have noticed that all my breakages have been inside and close to the hub of the wheel. I have not broken a journal in my experience, nor can I learn of one that ever was broken. I run my journals three inches and even less, two and seven-eight inches sometimes, and six inches in length, and my breakage has always occurred right close to the hub of the wheel. We turn the axle down generally about one-fourth of an inch and leave a shoulder which appears to stop the vibration, and

the axle breaks right there. I think that we can use our common axle, four and a half by three and a half inch journal and six inches long, when new. In fitting up axles I should leave a shoulder to shove the wheel against. I am satisfied that there is good result from that. The standard axle now proposed would cause a great deal of trouble if adopted. In fact I should not consider its adoption for a moment. I can increase my journals slightly without any alteration; I can use a four and a half inch axle in the rough without destroying my wheels. I have only to say further that I am opposed to adopting that standard axle, and I do not think that we should recommend it to the Convention.

Mr. FRY, Philadelphia & Erie Railroad—I would like to ask Mr. Wood, who was present at the Master Car Builders' Association, whether some statements were not made by some of the members as to the difference in the wearing of the brasses on different sized journals. It is unfortunate that none of us are giving any practical experience in this matter. The percentage of breakage in axles of common size has not been broached by any body, nor the use of brasses of different size. I am under the impression that the Master Car Builders' Association did bring forward some facts of this kind, and if so we would like to have the benefit of their experience.

Mr. WOOD, of New York City—There was in that Convention, as there seems to be in this, a scarcity of actual facts presented which would enable them to select the best size from the percentage of breakages and failures reported. But from the number of instances given the increase of the wheel-seat, or the side of journal close to the wheel-seat, was not upon the percentage reported. I think there were only ten or fifteen instances in which any details were given. There were a few instances given in which the axle was reported as breaking upon the inside of the shoulder of the journal. When, however, those cases were investigated it was, I think in every instance, decided that they were burned off rather than broken. Some reports on the steel axles and the tests that had been made by the Pacific Railroad had determined that there was a tendency with the steel axle to crack inside of the shoulder of the bearing point. I think there was only one instance in which a journal had failed or broken off while in transit. The other tests were those developed under the drop in testing axles, and incipient cracks were found encircling the journal at that point. Another fact that pressed strongly upon the Master Car Builders was the advantage of having a universal length quite as much as an increase of bearing. There was a variety of ideas among them as to the length and size of axle. It was stated that each one made his axles without regarding what his neighbors were doing. There were fifty or sixty different lengths of axles of all sizes produced. It was stated that it required a large stock of axles to be on hand in order to fit up cars that were on the road, by reason of the failure of foreign cars when traveling on any common road. Whether the size of the journals was to remain seven by three and three-quarter inches was not really decided upon nor discussed so

much as the standard lengths of axles agreed upon. It was desired to obtain the adoption of a uniform length of axle upon all the roads, even though the diameter of the journal should vary, in order that axles could be put under foreign cars without damaging the whole system. It is apparent to the members of this Convention, as it was to the members of the Master Car Builders' Association, that it does not matter so much what size of journal may be fixed upon, because the wear of the journal is continually going on, and we must have different sizes of brasses in hand to accommodate that wear. At the end of a few years three and three-fourths inch journals are reduced to three and five-eight inches, and then to three and a half, and finally down to three and three-eight inches, but they are still strong enough to do all the work that they are required to do. In recommending that length of axle, and the adoption of it by the Master Mechanics in connection with the Car Builders, I would suggest that we would have a point in favor of that axle that it would keep the length of axle the same, even though it should vary the size of the journal and of the wheel-seat. The derangement of the system is not so much in the wheel-seat and journal as it is in the variation in the length. In regard to the extra weight required at the wheel-seat the axle of itself is increased materially at that point. The extra weight is merely a binding fillet.

Mr. Brown, late of Erie Railroad—The question has been asked whether this size of journal was arrived at from experiments entered into in comparison with similar journals. I am under the impression that they have arrived at it through a series of experiments extending back through the past thirty years. Some thirty years ago they used to run cars with loads of six, eight, or ten tons, with journals of three inches in diameter and four and a half inches long; and they did it successfully, but not with the present lubricator. They had a lubricator which, in the way it was then put upon the journals, would not exude but acted to keep the metals apart. As the quantity of lubricator used increased they had to increase the journal in order to get sufficient space to use it. By adopting this journal you will indorse that practice on the part of those gentlemen who furnish the lubricator.

Mr. Peddle, Terre Haute & Indianapolis Railroad—I was very much pleased with the fairness of the report, but there was one point that was not enough dwelt upon, and that is the resistance of large journals. Mr. Forney stated one case on some road in Eastern Pennsylvania, where it was said that an engine with a large journal pulled fifteen cars, and one with a small journal eighteen cars on the same grade. I think that that is a matter we should look into in considering this question. I am satisfied that with a large journal it is much more difficult to start a train. I think the friction in starting, the taking of a revolving body from a state of rest, is much greater than it is when the body attains a velocity. I think that our engines are governed in their hauling capacity by their ability to start a train. If

we can move a large train with a smaller journal that fact should be considered.

Mr. FORNEY, Railroad Gazette—I would like to say it is true that one member, in replying to the circular, stated that he could pull more cars on a small journal than with a large one, but there were fifteen or sixteen who stated that they had never observed any difference. I have had a great deal of favorable testimony from experienced persons who say that in ordinary practice the large journals draw easier than the small ones. The Committee thought it only just and fair to give the exact testimony received in reply to their questions, whether it was favorable or unfavorable to their convictions, and they did so as far as they could. I hope that Mr. Richards, who has had some experience in the use of the standard axle, will give us the result of his observations. At the time this subject was under consideration before the Master Car Builders' Association, Mr. Garey, who has adopted the standard axle reported an experiment in which he took a car fitted with an axle having three different sizes of journals. He put brasses on the journals and put the car into service. He weighed each brass very carefully before putting it on. After running a certain distance he took them out and weighed them again. He found that the small brasses lost the most in weight, the middle size a little less, and the largest brasses lost the least in that service, showing that the friction of those journals was least with the largest bearing. If a large journal can be used with an inferior quality of oil it is an argument in favor of the large journal. If you can use cheaper oil with large journals than you can with small ones, I think that it is in favor of the large journals.

Mr. RICHARDS, Boston & Providence Railroad—We commenced using the standard axle eighteen months ago, at first on one car. It was on a line that caused a great deal of trouble because of sand and dust and hot boxes. The first car that we used we oiled every trip. We put it on double time and run it for three months. At last one of the boxes warmed, and we could not at the time find any cause for it. We oiled it and put it on double time again, running to New York and back twice; and some time afterward we had one of the axles out for a bad wheel, and found that a piece as large as the finger had gone out of the journal nearly its whole length. We commenced altering the whole line, and have used up the first hundred axles and have commenced on the second hundred. We are using a cheaper oil, and have far less trouble with our boxes. The axles are are no heavier than some of the axles that were standard on some of the Eastern roads—some roads are now using a heavier axle. I think that the wear of the boxes is no more, but rather less. We have altered all of one line of cars excepting two, and we have altered several cars for Mr. Wagner at his request. We have two tenders also running with the standard axle. I, for one, would not be tempted to go back to the old size.

Mr. GARFIELD, Hartford, Providence & Fishkill Railroad—I would like

to ask Mr. Richards if he ever tried a smaller journal on double time with a cheaper quality of oil, to see what the result would be.

Mr. RICHARDS, Boston & Providence Railroad—We used what we considered the best oil that we could buy on those cars, and it was difficult in summer time to get the cars through with that oil. Instead of putting them on double time we would frequently put them on half time; we were obliged to do it.

Mr. FRY, Philadelphia & Erie Railroad—I hope we will not forget that, if the Convention adopts the axle that is under discussion, it does not by any means bind every one to adopt it as a standard; it simply gives the expression of the Association as to their idea of the value of the axle, and this may lead to its adoption on new roads or under new stock. Whatever size of axle is adopted it will be inconvenient for old roads to make a change. The principal objection thus far urged against this standard axle is that it would cause so much alteration in the existing forms to adopt it. That objection would, however, apply to any form of axle. In regard to some other objections that have been urged it must be remembered that in matters of this kind we can not always adopt the best theoretical plan. We have sometimes to go for the best possible form. A great many roads have already adopted this axle, and that fact may, and I think should, have its weight in inducing us to vote for the standard which has some chance of being adopted. The remarks made by Mr. Wood as to the standard in length are very important, and should be considered. In regard to the size of the journal, I am under the impression that experiments were quoted in the Master Car Builders' Convention in support of a large journal. I think there is no doubt that with large journals there is a better chance for lubricating. The large journal was adopted, not with a view to add strength to the journal, but to insure better lubrication. I think that some members are under the impression that they would be obliged to adopt the axle if they voted in favor of the proposition before us, but I do not think that is the spirit of the proposition.

Mr. HUDSON, Rogers Locomotive Works—I have no doubt that the size recommended is well adapted to the existing acquirements of many of our railways on account of the weight that they carry in their cars. It is desirable to have a standard for use on foreign cars. That standard, however, would not apply to railways in regard to tender axles. We are in the habit of keeping tenders at home where we can attend to them if they need repairs. The difference of an inch in the size of the journal is necessary in many cases, when you make tenders carrying twenty-five or twenty-six hundred gallons of water. You then increase the weight beyond what can be safely carried, so far as lubrication is concerned, until you get it to, say, three and three-fourth inches by six. I am in favor, therefore, of increasing the length of the journal, and increasing the length necessarily increases the diameter of the wheel-seat, that has been increased also to avoid the breakage at the back of the wheel. I apprehend that it is not simply a matter of

how much you want to carry that will determine the size of the journal. I must say that I believe that three by six, or three and a quarter by six inches, is too small for the loads at present carried. I can recollect when journals on four-wheeled passenger cars were three and a half by one and three-fourth inches. The size has been gradually increased from year to year, and I know of numerous conventions that have met at different periods and have adopted a fixed standard size for the time, but they all failed to secure uniformity in the use of that standard, because they did not take into consideration the requirements of the future. We have got to deal with the present and the future will take care of itself. With regard to the length of the journal adapted to our present roads and the loads that we have to carry, I have no doubt that it would be wise to increase it from six to seven inches and even more.

Mr. Wells, Jeffersonville, Madison & Indianapolis Railroad—I presume there is not much difference of opinion with regard to the size of the journal, at least I have no objection to that size of journal. The only objection that I have to the axle is that there is more iron in it than is necessary under ordinary circumstances, and that it is not necessary to have an axle so large as four and seven-eight inches in diameter to carry an ordinary freight or platform car. There may be large sleeping cars or very heavy cars with which it might be an advantage to use the size recommended. So far as the journal is concerned I believe that three and a quarter inch journals are, perhaps, better than a smaller size, at least to begin with. The size of the journal that we use on our road, the standard size of freight and passenger cars, is three and a half by seven inches, which is a quarter of an inch smaller than the size recommended. I have no objection to the size of the journal.

Mr. White, Evansville & Crawfordsville Railroad—On our line we had a journal which was three and a quarter by seven inches, but it wore down to three and three-sixteenth inches and then broke at the inside collar. That was some two years ago. Since that time we have increased it a quarter of an inch, and I am now putting axles under the passenger cars with journals seven by three and a half inches. I have the same view as that expressed by Mr. Wells with reference to the weight of the axles. I do not think it is worth while to increase the entire length of the axle in size. Our wheel-seats are four and three-eight inches instead of four and seven-eighths, and in the center they are about three and seven-eight inches. The length is about the same as that recommended for the standard axle. This makes the axle considerably lighter, and they answer our purpose better from the fact that our cars are not so heavy as some of the cars on other roads. I think it should depend entirely upon circumstances—we do not need a very heavy axle under a class of light cars.

Mr. Robinson, Great Western of Canada—I would like to make a few remarks in regard to the axle in this respect. It seems to me that the ques-

tion is a more important one for cars than it is for tenders, and if we could for the time being, throw aside our ideas in regard to the locomotive department and tenders, to which this question refers, we could settle our minds a little more easily. We know that tenders do not go from one road to another; there is no exchange of tenders made, but between the different railroads there is an interchange of car rolling stock. I, for one, would not like any thing done at this Convention that would disturb what has already been done at so great a sacrifice of time and trouble by the Car Masters' Convention. We have taken no definite action in regard to this matter, but they have. I believe that they have done the best they could; until there is a better standard proposed let us use the standard recommended by them. It is better to have this axle, and even if we disapprove of it in the minority it is better to have that than none at all for a standard. I would therefore recommond to Mr. Forney that he modify the resolution and make it more acceptable to this Convention by putting it in this shape: *Resolved*, That this Convention regard the standard axle as recommended by the Car Masters' Convention as a suitable standard for car rolling stock. That means that we approve of it as a suitable standard for car rolling stock only.

Mr. Forney, Railroad Gazette—I think that the resolution as it now reads is substantially that. I would say in reply to what Mr. Hayes has said that I do not conceive that a recommendation of this size as the standard axle obliges every body to throw away their present axles and put in this. That would be absurd, no railroad company would go to that expense. But at the time this subject was before the Master Car Builders' Association they took great pains to learn from the different railway companies what were the standard axles in use on the different lines. They printed a table of those axles. I think that there were seventy-two different sizes of standard axles. If we could agree upon any standard it would be an advantage, of course. What I hope to accomplish by this resolution is to induce new railroad companies to adopt an axle uniform with that in use on other roads. At present there is no standard for them to go by, consequently they are quite at sea as to what they should adopt. By this resolution we merely say to them that if it is convenient to adopt this standard size of axle we advise it. I hope the members will not get the impression that we propose to recommend that all railroad companies take their old axles out and throw them away, and put the standard axle in. We do not propose any thing of that sort.

The President—The motion before the Convention is on the adoption of the resolution as offered by the Committee, "That this Association concur with the Master Car Builders' Association in recommending the adoption of the standard axle for car and tender axles which that Association has proposed, when said axles are to be made of iron." Are you ready for the question?

The sense of the Convention was expressed by the showing of hands, but the President was unable to determine whether the resolution was adopted. A standing vote was then taken with this result: for the resolution, 23; against the resolution, 35. The President therefore declared the resolution rejected.

THE PRESIDENT—The next business in order is the election of officers for the ensuing year. Article II of the Constitution provides:

"SECTION 1. The officers of the Association shall be a President, a Firs and Second Vice-President, a Secretary, and a Treasurer.

"SEC. 2. The above-named officers shall be elected separately, by ballot, at a regular meeting, and a majority of all votes cast shall be be necessary to a choice.

"SEC. 3. The officers shall be elected for a term of one year, but in the event of the election being postponed shall continue in office until their successors shall be elected.

"SEC. 4. Two tellers shall be appointed by the President to conduct the election and report the result."

I will appoint as tellers for this election Messrs. Sedgley and Wells. It will be better before the election to take a recess for a few minutes to enable the members to prepare their votes.

Mr. GRAHAM, Lackawanna & Bloomsburg Railroad—I move that the election of officers be postponed for one year.

The motion was seconded by Mr. Sedgley.

THE PRESIDENT—The motion before the Convention is that the election of officers be postponed for one year. Before putting the question I will say that, as President of the Association, I was intending to state before the election took place that I have thought it would be better for the Association to make selection of a new President. Of course, I am thankful for the honor you have conferred upon me, and have tried to do the best I could, but I think it would satisfy the officers generally if there were an election. There was no election last year. We, of course, take it very kindly that you seek to keep us in office by deferring the election, and if the Convention see fit I must put the vote.

Mr. ROBINSON, Great Western of Canada—I think it would be due to myself, as well as due to you that I should inform the Convention that, in the course of a few months I shall be out of the railway business, as I have accepted a very advantageous offer to take charge of another business. At the same time my love for railway life is such that I shall continue a member of your Convention and a Master Mechanic in spirit, and in so far as I may be able shall help the Association all I can. I think a great deal of this Association, and I shall always be one with you in heart and feeling It is due to you that I should state this, for I do not want you to elect an officer unless you think that he is in every way fitted for the trust you repose in him.

The President then put the motion that the election of officers be postponed for one year, and it was unanimously carried.

Mr. Hayes moved that a Committee of three be appointed to draft resolutions.

Carried.

The President appointed on such Committee Messrs. Fry, Sedgley, and Wells.

The Convention here took a recess for ten minutes.

THE PRESIDENT—The Committee on Assessment is ready to make their report. The report is in the hands of the Secretary.

Report of Committee on Assessment.

To the American Railway Master Mechanics' Association:

GENTLEMEN—Your Committee on Assessment would report that they have collected eleven hundred and thirty-three dollars, as follows:

For assessment for current year	$1,060 00
For back dues	60 00
For initiation fee	13 00
Total	$1,133 00

Respectfully submitted,

WILLIAM WOODCOCK,
A. J. SANBORN,
J. K. TAYLOR, } *Committee.*

On motion, the report was received.

THE PRESIDENT—The compensation of your Secretary has not yet been paid. What action will you take in regard to it?

Mr. PHILBRICK, Maine Central Railroad—I move that the usual compensation be paid the Secretary.

Mr. SELLERS, of Philadelphia—I understand that the duties of the Secretary have increased very largely during the past year.

THE PRESIDENT—They are increasing all the time.

Mr. SELLERS, of Philadelphia—The size of the volume published last year indicates a geeat deal of labor. I have no knowledge in regard to these matters, but I should like to see those who do the work by which we are all benefited fully compensated for their labor.

Mr. HAYES, Illinois Central Railroad—I would like to move an amend-

ment to the resolution of Mr. Philbrick, that the amount paid the Secretary be $750 instead of $500.

Mr. Philbrick accepted the amendment, and the resolution was then adopted.

THE PRESIDENT—I am informed by the Committee on Arrangements that the use of this hall has been kindly donated to us by the Trustees of the Cooper Union, and it is highly proper that some resolution thanking them for the use of the hall be adopted.

Mr. Brooks offered the following resolution, which was seconded by Mr. Sedgley and unanimously adopted:

Resolved, That the American Railway Master Mechanics' Association, in convention assembled, hereby tender their sincere thanks to the Trustees of the Cooper Union for the free use of this hall for the Eighth Annual Convention of this Association, and that this Association publicly express their appreciation of the eminent services in the advancement of the cause of education and science rendered by Mr. Peter Cooper, the venerable founder of the Cooper Union.

Mr. PETER COOPER—I would reply in behalf of the Trustees that you are entirely welcome to the use of this hall. We are glad to have it used for so useful a purpose, and you will be welcome to it at any future time when you may find it convenient to occupy it. This building is devoted to the welfare of the community, and whenever it can contribute to that end so effectually as it does in giving place for such a meeting as this it will be a source of peculiar pleasure to myself and to the Trustees. I will state to you what I mentioned to your President just now, that, if agreeable, when you adjourn, I would like to have you follow me through the rooms of the Cooper Union, that you may see the work that is being accomplished here. The rooms on this floor are occupied at night by boys, and the rooms below are occupied by the girls in the day, and I may be able to show you only the rooms that are occupied at night.

THE PRESIDENT—Is the Committee on Resolutions ready to report?

Mr. Fry, the Chairman of the Committee on Resolutions, submitted the following, which were unanimously adopted:

Report of Committee on Resolutions.

To the American Railway Master Mechanics' Association:

Resolved, That the thanks of this Association be presented to the Merchants and Manufacturers who have so kindly and respectfully welcomed us to the City of New York, the great commercial center of the continent, and to the several Committees for their various and agreeable entertainments which have been so well and so unos-

tentatiously managed. To the Rev. Dr. Pullman, who opened the session of this Association by an eloquent appeal to our Supreme Ruler for guidance in our deliberations and strength to carry out the duties imposed on us by our officers. To the Press of the City of New York for their report of our proceedings, and to the Railroads who have extended to us facilites of passes, etc.

Respectfully,

HOWARD FRY,
JAMES SEDGLEY, } *Committee.*
R. WELLS,

Mr. SELLERS, of Philadelphia—It may be considered that the manner in which the election of officers has been divested shows our appreciation of the services of those gentlemen, but it seems to me that, in consideration of the very great good that they have done the Association, the members should offer them a special vote of thanks, and I therefore beg leave to offer the following resolution:

Resolved, That the thanks of this Association be tendered to its officers who have labored so zealously in their respective places, a labor confined not alone to the time of meeting, but extending through the entire year and contributing very largely to our success.

The resolution was unanimously adopted.

THE PRESIDENT—Gentlemen, I thank you very kindly for this expression of your favor, and I hope in future you may have no cause to regret any thing that you have done to-day. I will endeavor to do the best that I can, and, with the assistance of the officers you have elected on the staff, I trust may be able to do what is for the best interests of the Association. Is there any other business to come before this Association? Before we adjourn I would like to say one word more to each and every member, and that is that we must strive this year to answer the circulars of the committees earlier and more fully than hitherto, in order that they may have them in time to compile their reports. The success of this Association depends in a great degree upon the reports read and discussed in open convention. We meet here to get at the facts which are of interest and importance to us. These facts can be reached in no other way than by the Master Mechanics stating their experiences, either to committees or in convention, or both. As has been said here several times during the past few days, scientific men, not only in this country but in Europe, are looking for the experience of the members of this Association. They need the result of our experiments to determine what course they shall adopt in the mechanical department of their railways. The success of our Association depends upon the efforts of the individual members. We hope that every member this year will try to do a

little more than he has done before, and to do his duty more promptly. Instead of three or four hundred pages in our Annual Report, we would like to have a volume of a thousand.

Mr. FORNEY, Railroad Gazette—I have had applications, from time to time, from parties who are not members of the Association, inquiring whether the reports of the Master Mechanics' Association could be purchased or procured. I do not know whether the Association has ever taken any action with regard to selling the reports. If not, I would move that the reports of the Association be offered for sale by the Executive Committee.

Mr. SETCHEL, Little Miami Railroad—In answer to Mr. Forney's question I would state that, at a meeting of the Supervisory Committee held some months ago, the Secretary was instructed to charge one dollar per copy for reports furnished to those outside of the railroad business and having no connection with the Association. That direction has been adhered to, and we have received from that source, as reported, the sum of $17.14.

Mr. FORNEY, Railroad Gazette—That covers exactly what I had in view, but I would suggest that public announcement be made to that effect.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—Some reference has been made to the subjects for investigation during the next year. I would like to call the attention of the Convention to one subject that will be presented, and that is as to the form, material, and proportions of locomotive boilers and fire boxes. The fuel expense of locomotives is probably greater than that of repairs, and it is a matter of very great importance. The great question for us to determine is whether we have yet secured the proper form and proportions for fire boxes; whether we have the best form that can be adopted for economy of fuel; whether we have arrived at the limit of economy in that direction. It seems to me that the only way to ascertain that is by making very careful experiments and investigations. Where you have boilers that are of different sizes and proportions doing the same work you have an opportunity to ascertain whether the proportions or forms have any considerable effect on the amount of fuel consumed. It seems to me we have not so far given much attention to this matter, at least not the attention that the subject requires. It is one of very great interest to all, and it may be of very great profit if we carefully investigate it during the coming year.

Mr. SELLERS, of Philadelphia—I do not know whether the Committee in charge of the subjects for discussion for the next year have thought it proper to solicit information in regard to the shape of the flange of the tire for locomotives. I had given to me yesterday a paper showing the profile of a tire used on some railroads, and recommended for general adoption by various parties, and it was the wish of the Midvale Steel Works to obtain a suggestion from this Association as to the proper form of profile of flange tire for locomotives. Is there a possibility of having that information obtained through this Association?

THE PRESIDENT—We will entertain any motion that you may make

to get at the facts, but I think the better way for the Midvale Steel Works would be to send a circular requesting information to each member of the Association.

Mr. Brooks, Brooks Locomotive Works—That would depend in a great measure upon the character of the service the tire is intended to perform—that is, the frogs that it is intended to run through. On some roads in Europe the flange has an office to perform that it does not have in this country. There the flange is supposed to carry the weight through the frogs on a double inclined plane, and in such case it has to be entirely different from what it is here. I know that, because I have had most of the flanges of the Krupp tire which I have used, changed. They were formerly sent here with the same profile that they have in Europe. As to the shape of tires there are just about as many different opinions as there are Master Mechanics. I hardly think that there is a template that will fit in any two shops. The form of tire now used by Krupp people will turn up in any shape of flange that our American people want. Is not that so, Mr. Hudson?

Mr. Hudson, Rogers Locomotive Works—I believe that is correct. They have changed their form recently, and make it come to a very sharp edge—too sharp, indeed. In ordering tires we send a special template to make them.

Mr. Fry, Philadelphia & Erie Railroad—I deem it of great importance that the members of the Association should receive our Annual Report at the proper time; but to save our Committee from trouble I would propose to not have the Annual Report sent to members who have not paid their assessment. I think if it is not sent it will act as a hint to some who may have forgotten their dues, and perhaps bring in an assessment otherwise forgotten. I would therefore offer it as a resolution, that the Annual Report be not sent to any member who has not paid his assessment.

Mr. Brooks, Brooks Locomotive Works—As I understand the motion it is intended to apply only to those members who have not paid their assessment as prescribed by the Constitution.

The President—That is so, and it will be six months before the report is ready.

The resolution of Mr. Fry was then adopted.

On motion of Mr. Sellers, the Convention then adjourned.

COMMITTEES AND SUBJECTS FOR DISCUSSION AT THE NINTH ANNUAL CONVENTION.

1.

Locomotive Tests.

M. N. FORNEY, Railroad Gazette;
R. H. THURSTON, Stevens' Institute;
W. WOODCOCK, Central of New Jersey.

2.

Locomotive Construction.

JAS. SEDGLEY, Lake Shore & Michigan Southern;
H. G. BROOKS, Brooks Locomotive Works;
H. FRY, Philadelphia & Erie;
W. S. HUDSON, Rogers Locomotive Works;
S. A. HODGMAN, Philadelphia, Wilmington & Baltimore.

3.

Locomotive Tire, Truck and Tender Wheels.

A. B. UNDERHILL, Boston & Albany;
J. THOMPSON, Eastern;
F. A. WAITE, Boston & Maine;
GEO. RICHARDS, Boston & Providence.

4.

Best and Most Economical Metal for Locomotive and Tender Bearings.

JOHN ORTTON, Great Western of Canada;
F. M. WILDER, Erie;
PETER CLARK, Northern of Canada.

5.

Is it Economical to Use Injectors on Locomotives, and to What Extent?

E. T. JEFFERY, Illinois Central;
J. A. JACKMAN, Chicago, Alton & St. Louis;
GEO. CUSHING, Missouri, Kansas & Texas.

6.

The Best Material, Form, and Proportion of Locomotive Boilers and Fire Boxes.

R. WELLS, Jeffersonville, Madison & Indianapolis;
C. R. PEDDLE, Terre Haute & Indianapolis;
S. J. HAYES, Illinois Central;
S. M. CUMMINGS, Pittsburgh, Fort Wayne & Chicago;
L. S. YOUNG, Cleveland, Columbus, Cin. & Indianapolis.

7.

Boiler Explosions.

WESTERN COMMITTEE—

H. M. BRITTON, Cincinnati;
R. WELLS, Jeffersonville, Madison & Indianapolis;
C. R. PEDDLE, Terre Haute & Indianapolis;
J. H. SETCHEL, Little Miami;
S. M. CUMMINGS, Pittsburgh, Fort Wayne & Chicago;
N. E. CHAPMAN, Cleveland & Pittsburgh.

EASTERN COMMITTEE—

H. M. BRITTON, Cincinnati;
A. B. UNDERHILL, Boston & Albany;
H. L. BROWN, New Lebanon, N. Y.;
J. H. FLYNN, Western & Atlantic;
THOMAS KERR, Camden & Amboy;
W. A. ROBINSON, Great Western of Canada;
J. W. PHILBRICK, Maine Central;

8.

Finance.

G. W. STRATTAN, Pennsylvania;
J. U. EASTMAN, Nashville & Chattanooga;
C. T. HAM, Buffalo Steam Gauge Co.

9.

Trustees Boston Fund, Printing and General Supervisory Committee.

H. M. BRITTON, Cincinnati;
N. E. CHAPMAN, Cleveland & Pittsburgh;
W. A. ROBINSON, Great Western of Canada;
S. J. HAYES, Illinois Central;
J. H. SETCHEL, Little Miami.

10.

Arrangements for Ninth Annual Meeting.

COLEMAN SELLERS, Philadelphia;
E. H. WILLIAMS, Baird & Co., Philadelphia;
W. B. BEMENT, Philadelphia.

CONSTITUTION

AS AMENDED AT THE SIXTH ANNUAL MEETING, BALTIMORE, MAY 13, 1873.

PREAMBLE.

WE, the undersigned, Railway Master Mechanics believe that the interests of the Companies by whom we are employed may be advanced by the organization of an Association which shall enable us to exchange information upon the many important questions connected with our business. To this end do we establish the following

CONSTITUTION.

ARTICLE I.

SECTION 1. The name and style of this Association shall be the AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

ARTICLE II.

SEC. 1. The officers of the Association shall be a President, a First and Second Vice-President, a Secretary, and a Treasurer.

SEC. 2. The above-named officers shall be elected separately, by ballot, at a regular meeting, and a majority of all votes cast shall be necessary to a choice.

SEC. 3. The officers shall be elected for a term of one year, but in the event of the election being postponed shall continue in office until their successors shall be elected.

SEC. 4. Two tellers shall be appointed by the President to conduct the election and report the result.

ARTICLE III.

SEC. 1. It shall be the duty of the President to preside in the usual manner at all the meetings of the Association, and approve all bills against the Association for payment by the Treasurer.

SEC. 2. It shall be the duty of the Vice-Presidents, according to rank, to perform the duties of the President in his absence from the meetings of the Association.

SEC. 3. In case of the absence of both President and Vice-Presidents, the members present shall elect a President *pro tempore*.

SEC. 4. It shall be the duty of the Secretary to keep a full and correct record of all transactions at the meetings of the Association; to keep a record of the names and places of residence of all members of the Association, and the name of the road they each represent; to receive and keep an account of all money paid to the Association, and at the close of each meeting deliver the same to the Treasurer, taking his receipt for the amount; to receive from the Treasurer all paid bills, giving him a receipted statement of the same.

SEC. 5. It shall be the duty of the Treasurer to receive all money from the Secretary belonging to the Association; to receive all bills against the Association, and pay the same, after having the approval of the President; to deliver all paid bills to the Secretary at the close of each meeting, taking a receipted statement of the same; to keep an accurate book account of all transactions pertaining to his office.

ARTICLE IV.

SEC. 1. The following persons may become members of the Association by signing the Constitution, or authorizing the President or Secretary of the Association to sign for them, and pay the initiation fee of one dollar. Any person having charge of the Mechanical Department of a Railway known as "Superintendents," or "Master Mechanics," or "General Foremen," the names of the latter being presented by their superior officers for membership. Also, two Mechanical Engineers or the representative of each Locomotive Establishment in America.

SEC. 2. Civil and Mechanical Engineers and others whose qualifications and experience might be valuable to the Association may become Associate Members by being recommended by three active members. Their names shall then be referred to a committee, which shall report to the Association on their fitness for such membership. Applicants to be elected by ballot at any regular meeting of the Association, and five dissenting votes shall reject. The number of Associate Members shall not exceed twenty. Associate Members shall be entitled to all the privileges of active members excepting that of voting.

SEC. 3. Any person who has been or may be duly qualified, and signs, or causes to be signed, the Constitution, as member of the Association, remains as such until his resignation may be voluntarily tendered.

SEC. 4. All members of the Association will be liable for such dues as may be necessary to assess to defray the expenses of the Association, and any

member who shall be two years in arrears for annual dues shall have his name stricken from the roll, and be duly notified of the same by the Secretary.

ARTICLE V.

SEC. 1. The regular meeting of the Association shall be held annually on the second Tuesday in May.

SEC. 2. Regular meetings shall be held at such place as may be determined upon by a majority of the members present at the previous meeting.

SEC. 3. An adjourned meeting may be held at any time and place that a majority of the members present at any meeting may elect.

SEC. 4. The regular hours of sessions shall be from 9 o'clock A. M. to 2 o'clock P. M.

SEC. 5. During the business sessions no communications shall be received or acted upon other than those pertaining to the business of the Association.

ARTICLE VI.

SEC. 1. This Constitution may be amended at any regular meeting of the Association by two-thirds vote of the members present.

Resolution passed at the Sixth Annual Meeting, Baltimore, May, 1873.

Resolved, That no expense shall be incurred by committees except by the unanimous consent of the General Supervisory Committee, given in writing to the chairman of said committees, stating the amount to be expended.

Resolution on Boston Fund.

Resolved, That the Boston Fund, amounting now, with accrued interest, to \$3,620, be invested in Government securities to be selected by the duly appointed Trustees, and not to be disturbed for the purpose of expenditure unless authorized by the majority of members present in open convention, and then only after due notice of a motion to expend the same has been given at the session immediately preceding; and that the interest accumulating shall every year be invested in the same manner as the principal, and a full account of the same be duly reported with other financial statements.

NAMES AND ADDRESS OF MEMBERS.

NAME.	ROAD.	ADDRESS.
Anderson, H.		156 Lake st., Chicago.
Anderson, J. H	N. Y. B. & P. Rd	Providence, R. I.
Adams, G. Q	Q. M. & P. Rd	Kirksville, Mo.
Alden, H. A	C. C. & B. & O. Rd	Brockville, Ont.
Britton, H. M	N. Y. & N. E. Rd	Boston, Mass.
Boon, J. M	P. Ft. W. & C. Rd	Fort Wayne, Ind.
Baer, R. B	T. & N. O. Rd	Houston, Texas.
Bushnell, R. W	B. C. R. & M. Rd	Cedar Rapids, Iowa.
Brastow, L. C	L. & S. Rd	Ashley, Pa.
Brown, H. L		New Lebanon, N. Y.
Blackall, R. C	A. & S. Rd	Albany, N. Y.
Boyden, G. E	B. H. & E. Rd	Boston, Mass.
Burroughs, A. P	M. & O. Rd	Marquette, Mich.
Brooks, H. G	Brooks Locomotive Works	Dunkirk, N. Y.
Brown, C. H		Utica, N. Y.
Britton, A. W	C. & W. V. Rd	Harrison, O.
Burferd, H. N	M. & C. Rd	Huntsville, Ala.
Blackburn, V	Erie Rd	Jersey City, N. J.
Brewer, S. E	N. Y. N. H. & H. Rd	Hartford, Conn.
Chapman, J. W	Erie Rd	Hornellsville, N. Y.
Cullen, Wm		219 Barr st. Cincinnati
Cooper, W. E		Dunkirk, N. Y.
Chapman, N. E	C. & P. Rd	Cleveland, Ohio.
Cummings, S. M	P. Ft. W. & C. Rd	Allegheny, Pa.
Coolidge, G. A	F. Rd	Charlestown, Mass.
Clark, David	L. V. Rd	Hazleton, Pa.
Cooper, H. L	H. & St. Joe Rd	Hannibal, Mo.
Church, Foster	T. & B. Rd	Troy, N. Y.
Collings, E	C. & A. Rd	Camden, N. J.
Colburn, R	N. & W. Rd	Norwich, Conn.
Cook, James	Danforth & Cook's Locomotive and Manufacturing Co	Paterson, N. J.
Cushing, Geo	M. K. & T. Rd	Sedalia, Mo.

NAME.	ROAD.	ADDRESS.
Curtis, Robert	P. C. & St. L. Rd	Columbus, Ohio.
Crockett, John F	B. L. & N. Rd	Boston, Mass.
Clark, Peter	N. Rd. of Canada	Toronto, Canada.
Child, F. D	Hinkley Locomotive Works	Boston, Mass.
Cascaddin, R. O	C. R. I. & Pac. Rd	Trenton, Mo.
Cook, Leo L	B. & A. Rd	Brunswick, Ga.
DeClercq, A. H	In. & G. N. Rd	Hearne, Texas.
Devine, J. F	W. & W. Rd	Wilmington, N. C.
Drippes, Isaac	P. Rd	3405 Walnut st., West Philadelphia.
Davies, D. T	V. & M. Rd	Fitchburg, Mass.
Duncan, Wm		Worcester, Mass.
Dohoney, R. V	Late A. & E. Rd	Baltimore, Md.
Dripp, W. A	N. Y. & O. M. Rd	Philadelphia, Pa.
Eddy, Wilson	B. & A. Rd	Boston, Mass.
Elliott, Henry	Late O. & M. Rd	East St. Louis, Mo.
Edams, J. B	I. C. Rd	Amboy, Ill.
Evans, Thomas	C. & F. Rd	Catasauqua, Pa.
Erwin, J. H	G. B. & M. Rd	Fort Howard, Wis.
Eastman, J. U	N. & C. Rd	Nashville, Tenn.
Ellis, J. C	Schenectady Locomotive Works	Schenectady, N. Y.
Eastman, C. L	C. Rd	Concord, N. H.
Elder, Jos	R. R. I. & St. L. Rd	Beardstown, Ill.
Elliott, C. C	C. & N. W. Rd	Clinton, Iowa.
Ellis, W. H	P. & R. Rd	Catawissa, Pa.
Foss, J. M	C. V. Rd	St. Albans, Vt.
Fry, Howard	P. & E. Rd	Williamsport, Pa.
Flynn, J. H	W. & A. Rd	Atlanta, Ga.
Fuller, Wm	A. & G. W. Rd	Meadville, Pa.
Fellows, Chas	Late L. S. & T. V. Rd	Cleveland, Ohio.
Faries, H. V.	A. T. & S. F. Rd	Topeka, Kansas.
Finlay, L	C. & F. Rd	Little Rock, Ark.
Fields, W. A	P. & O. Rd	Portland, Maine.
Funk, J. S	N. C. Rd	Marysville, Pa.
Foster, W. L	P. & E. Rd	Renovo, Pa.
Foster, W. A	W. & M. Div. F. Rd	Fitchburg, Mass.
Gibbs, E. B		St. Louis, Mo.
Graham, Chas	L. & B. Rd	Kingston, Pa.
Glass, G. W	A. V. Rd	Pittsburgh, Pa.
Garfield, E	H. P. & F. Rd	Hartford, Conn.
Garrett, H. D	P. Rd	West Philadelphia.

NAME.	ROAD.	ADDRESS.
Gorman, T. G	M. K. & T. Rd	Springfield, Ill.
Grant, B. D.		
Griggs, W. H	N. Y. & O. M. Rd	Oswego, N. Y.
Griggs, Albert	W. & N. Rd	Worcester, Mass.
Granger, W. E	W. & B. R. Rd	Utica, N. Y.
Gassett, L. O	L. S. & M. S. Rd	South Cleveland, Ohio.
Gould, A	N. Y. C. & H. R. Rd	Rochester, N. Y.
Gould, F		Middletown, Orange Co., N. Y.
Gilbert, W. G	P. & St. L. Rd	Portland, Oregon.
Hanford, Henry	N. Rd	Bridgeport, Conn.
Hipple, W. H	Late T. & P. Rd	Marshall, Texas.
Hayes, S. J	Ill. Cent. Rd	Chicago, Ill.
Hill, E. O	Erie Rd	New York City.
Holloway, J. W	C. Mt. V. & D. Rd	Akron, Ohio.
Ham, C. T	Buffalo Steam Gauge Co	Buffalo, N. Y.
Hull, A. S	C. V. Rd	Chambersburg, Pa.
Hudson, W. S	Rogers Locomotive Works	Paterson, N. J.
Hibberd, A. W	Jefferson City Iron Works	Jefferson City, Mo.
Hewitt, John	A. & P. Rd	St. Louis, Mo.
Haynes, O. A	St. L. & I. M. Rd	Carondalet, Mo.
Healy, B. W	Rhode Island Locom've Works	Providence, R. I.
Hollister, C. W	Valley Rd	Hartford, Conn.
Hubbard, J. G	Erie Rd	Buffalo, N. Y.
Hodgman, S. A	P. W. & B. Rd	Wilmington, Del.
Hain, F. K	Erie Rd	Susquehanna, Pa.
Hanglin, J. A	Texas Pacific Rd	Marshall, Texas.
Hill, Rufus	C. & A. Rd.	Camden, N. J.
Haggett, J. C	D. A. V. & P. Rd	Dunkirk, N. Y.
Harding, B. R	R. & G. Rd.	Raleigh, N. C.
Johann, Jacob	T. W. & W. Rd	Springfield, Ill.
Jackman, J. A	C. A. & St. L. Rd	Bloomington, Ill.
Jones, Thomas	C. & F. Rd	Catasauqua, Pa.
Jeffery, E. T	I. C. Rd	Chicago, Ill.
Johnson, J. D	C. & A. Rd	Chicago, Ill.
Kinsey, J. I	L. V. Rd	Easton, Pa.
Kelly, Jos	P. & W. Rd	Providence, R. I.
Kerr, Thomas	C. & A. Rd	Bordentown, N. J.
Keeler, Sanford	F. & P. M. Rd	Marquette, Mich.
Kidder, B. H		Buffalo, N. Y.
King, Robert	C. C. & A. Rd	Columbia, S. C.

NAME.	ROAD.	ADDRESS.
Kilby, G. S	C. & P. Rd	Lyndonville, Vt.
Losey, Jacob	L. N. A. & C. Rd	New Albany, Ind.
Losee, T. V	I. B. & W. Rd	Urbana, Ill.
Little, H. A		2043 Tower st., Philadelphia, Pa.
Lewis, C. M	N. C. Rd	Baltimore, Md.
Lauder, J. N	N. Rd	Concord, N. H.
Landis, H. D	B. & S. S. Rd	Bellefonte, Pa.
Leech, H. L	Hinkley Locomotive Works	Boston, Mass.
Logan, P. A	N. B. Rd	Fredrickton, N. B.
Lininger, W	P. V. & C. Rd	Pittsburgh, Pa.
Lingle, Thomas	C. & O. Rd	Richmond, Va.
Lewis, W. H	D. L. & W. Rd	Hoboken, N. J.
Losey, Fred. C		120 Park ave., Jackson, Mich.
Lannon, Wm	W. M. Rd	Union Bridge, Md.
Ladd, J. J		Litchfield, Ill.
Lamb, James	C. B. & Q. Rd	Galesburg, Ill.
LaSeur, W	F. N. S. & C. Rd	College Point, L. I.
Munro, J. C	St. P. & P. Rd	St. Paul, Minn.
Moore, S	P. Ft. W. & C. Rd	Allegheny. Pa.
Mulligan, J	C. R. Rd	Springfield, Mass.
Mitchell, A	W. Div. L. V. Rd	Wilkesbarre, Pa.
McKenna, J	I. P. & C. Rd	Peru, Ind.
McAllister, W	W. J. Rd	Camden, N. J.
McFarland, Jas	M. & M. Rd	Montgomery, Ala.
McFarland, John	R. & D. Rd	Richmond, Va.
McCrum, J. S	M. R. Ft. S. & G. Rd	Kansas City, Mo.
McDougall, R	M. C. & O. Rd	Whistler, Ala.
McVey, John	W. Rd. of A	Montgomery, Ala.
Maynes, A. G	S. R. & D. Rd	Selma, Ala.
Montgomery, James	L. & N. Rd	Bowling Green, Ky.
Morse, G. F	Portland Locomotive Works	Portland, Maine.
Martin, J. N	G. T. Rd	Portland, Maine.
Mead, L. T	W. W. Rd	Hudson, Wis.
Morgan, J. B	C. D. & V. Rd	Danville, Ill.
Morris, C. R	Housatonic Rd	Falls Village, Conn.
Metzger, Chas	L. C. & L. Rd	Louisville, Ky.
Morse, J. B	T. W. & W. Rd	Fort Wayne, Ind.
McDowell, R	B. D. Rd	Lambertville, Pa.
Noble, L. C	H. & T. C. Rd	Houston, Texas.

NAME.	ROAD.	ADDRESS.
Noyes, Warren	E. Div. G. T. Rd	Gorham Station, N. H.
Ortton, John	G. W. Rd	Hamilton, Can.
Osborne, Ezra	Grant Locomotive Works	Paterson, N. J.
Pendleton, M. M.	S. & R. Rd	Portsmouth, Va.
Perry, F. A.	C. & A. Rd	Keene, N. H.
Perry, G. W.	Late P. W. & B. Rd	Wilmington, Del.
Parks, W. M	T. & B. Rd	Taunton, Mass.
Philbrick, S. M	L. L. & G. Rd	Lawrence, Kansas.
Perrin, P. J.	Taunton Locomotive Works	Taunton, Mass.
Prescott, A. J.	C. Rd	Catawissa, Pa.
Peddle, C. R.	T. H. & I. Rd	Terre Haute, Ind.
Philbrick, J. W	M. C. Rd	Waterville, Maine.
Prescott, G. H.	P. C. & St. L. Rd	Logansport, Ind.
Purves, T. B	W. Div. of B. & A. Rd	Greenbush, N. Y.
Place, T. W	I. C. Rd	Waterloo, Iowa.
Potts, J. D. W	O. & M. Rd	Seymour, Ind.
Ray, W. F	T. W. & W. Rd	Fort Wayne, Ind.
Richards, George	B. & P. Rd	Boston, Mass.
Roop, F	N. P. Rd	Philadelphia, Pa.
Robinson, W. A.		Hamilton, Canada.
Robinette, J. T.	S. S. Rd	Petersburg, Va.
Rowley, W. D	K. C. St. Jo. & C. B. Rd	St. Joseph, Mo.
Ross, Anthony	M. & C. Rd	Memphis, Tenn.
Robb, W. D	L. P. & S. M. Rd	Elizabethtown, Ky.
Rennie, D. P	L. & N. Rd	Louisville, Ky.
Somers, A. H	P. Ft. W. & C. Rd	Valparaiso, Ind.
Strode, James	E. & C. Div. N. C. Rd	Elmira, N. Y.
Stevens, G. W	L. S. & M. S. Rd	Elkhart, Ind.
Skidmore, J	T. N. & G. S. Rd	Nashville, Tenn.
Shaver, D. O.	Pennsylvania Rd	Pittsburgh, Pa.
Smith, W. F	C. C. C. & I. Rd	Cleveland. Ohio.
Sellers, Morris		No. 6 Ashland Block, Chicago, Ill.
Setchel, J, H	L. M. Rd	Cincinnati, O.
Sellars, L. H	P. & L. Rd	Pensacola, Fla.
Smith, W. T.	P. & E. Rd	Erie, Pa.
Sedgley, James	L. S. & M. S. Rd	Cleveland, Ohio.
Strong, W. M	N. Y. & H. Rd	New York City.
Sanborn, A. J	I. & St. L. Rd	Mattoon, Ill.
Stearns, W. H	C. R. Rd	Springfield, Mass.
Sterk, F	V. & T. Rd	Lynchburg, Va.

NAME.	ROAD.	ADDRESS.
Smith, J. Y	Locomotive Builder.	Pittsburgh, Pa.
Stewart, C. E		819 Grove st., Elizabeth, N. J.
Smith, W. B	S. C. Rd	Charleston, S. C.
Slingland, N.	Western Rd	Hartford, Conn.
Sprague, H. N	Porter, Bell & Co	Pittsburgh, Pa.
Sechler, J. F	N. Y. & O. M. Rd	Worttendyke, N. J.
Steinberger, Samuel	J. M. & I. Rd	North Madison, Ind.
Salisbury, L. B	St. L. & S. E. Rd	Mt. Vernon, Ill.
Schlacks, H	I. C. Rd	Chicago, Ill.
Strattan, G. W	Pennsylvania Rd	Altoona, Pa.
Simpson, C. G. C	M. O. & W. Rd	Montreal, P. Q.
Thompson, J	P. Ft. W. & C. Rd	Crestline, Ohio.
Thompson, C. A	L. I. Rd	Hunter's Point, L. I.
Thompson, John	Eastern Rd	Boston, Mass.
Turreff, W. F.	L. S. & T. V. Rd	Black River, Ohio.
Towne, H. A	N. P. Rd	Brainerd, Minn.
Taylor, J. K	O. C. & N. Rd	Boston, Mass.
Tier, G. H	L. S. & M. S. Rd	Norwalk, Ohio.
Tull, C. H	N. L. & T. Rd	Monroe, La.
Thompson, A	Late O. & M. Rd	Seymour, Ind.
Underhill, A. B	B. & A. Rd	Boston, Mass.
Van Vetchen, J	Erie Rd	Port Jervis, N. Y.
Van Buskirk, W. G	D. & C. Rd	Fishkill, N. Y.
Walsh, Thomas	M. & O. of L. & N. Rd	Memphis, Tenn.
Warren, B	St. L. A. & T. H. Rd	St. Louis, Mo.
Wallace, W. L	L. S. & M. S. Rd	Buffalo, N. Y.
Wallace, H. S	C. & H. V. Rd	Columbus, Ohio.
Woods, H. E	C. R. I. & Pac. Rd	Rock Island, Ill.
Whitney, H. A	Intercolonial Rd	Moncton, N. B.
Wells, Reuben	J. M. & I. Rd	Jeffersonville, Ind.
Wright, N	A. & G. W. Rd	Cleveland, Ohio.
Wade, R. D	N. C. Rd	Company Shops, N. C.
Wiggins, J. E	M. K. & T. Rd	Hannibal, Mo.
Waite, F. A	B. & M. Rd	Boston, Mass.
Wilder, F. M	Erie Rd	Buffalo, N. Y.
Wood, M. P		32 Warren street, New York City.
Wills, J. C	T. W. & W. Rd	Lafayette, Ind.
Woodcock, W	Central Rd. of N. J	Elizabethport, N. J.
White, J. L	E. & C. Rd	Evansville, Ind.

NAME.	ROAD.	ADDRESS.
Waddy, J. E	O. A. & M. Rd	Alexandria, Va.
Williams, E. H	Baldwin Locomotive Works	Philadelphia, Pa.
Waugh, L. H	K. P. Rd	Armstrong, Kansas.
Weaver, D. S	E. K. Rd	Hunnewell, Ky.
Walls, Martin	P. & E. Rd	Sunbury, Pa.
White, Philip	C. & P. Rd	Wellsville, Ohio.
Woodruff, T. B	C. Rd. of Iowa	Eldora, Iowa.
Wilson, Wm	C. B. & Q. Rd	Galesburg, Ill.
Wallace, Robert.	Erie Rd	Susquehanna, Pa.
Young, L. S	C. C. C. & I. Rd.	Cleveland, O.

ASSOCIATE MEMBERS.

Bement, W. B.	21st and Callowhill streets	Philadelphia, Pa.
Evans, W. W	63 Pine street	New York City.
Forney, M. N	Railroad Gazette	73 Broadway, N. Y.
Holly, A. L		Troy, New York.
Lilly, J. O. D		Indianapolis, Ind.
Miles, F. B.		Philadelphia, Pa.
Morton, Henry		Hoboken, N. J.
Nott, G. H		Boston, Mass.
Rogers, J. G.		Madison, Ind.
Sellers, Coleman		Philadelphia, Pa.
Thurston, R. H	Professor at Stevens' Institute	Hoboken, N. J.
Wheelock, Jerome		Worcester, Mass.

ORDER OF BUSINESS.

1. Reading the Minutes of previous meeting.
2. Calling the Roll of Members.
3. Signing the Constitution.
4. Report of Secretary.
5. Report of Treasurer.
6. Report of Committees appointed at a previous meeting.
7. Election of Officers.
8. Appointment of a Committee to suggest Subjects for Consideration.
9. Appointment of Miscellaneous Committees: on Finance, Printing, and Place for holding next Annual Meeting.
10. Report of Committee to suggest Subjects for Consideration.
11. Appointment of Committees to report upon Subjects suggested for Consideration.
12. Unfinished Business.

H. M. BRITTON,
N. E. CHAPMAN,
W. A. ROBINSON, *Committee.*
S. J. HAYES,
J. H. SETCHEL,

INDEX.

The next Annual Meeting will be held at Philadelphia, Tuesday, May 9, 1876, unless postponed as authorized by a vote of last Convention, in which case due notice will be given.